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Effect of Fluid Administration on Fluid Consumption and Hydration Status

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EFFECT OF FLUID ADMINISTRATION ON FLUID CONSUMPTION

AND HYDRATION STATUS

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ABSTRACT

The use of an external fluid administrator (EFA) to deliver fluids is a recent phenomenon in athletics. However, this has yet to be compared to the traditional method of self administration (SA).

PURPOSE: To examine the influence fluid administration methods have on fluid consumption, hydration status, and perceptual variables.

METHODS: Nineteen recreationally active individuals [14 males, 5 females (30±10y; 176±8cm; 72.5Kg) participated in two days of exercise with varying the method of fluid administration (self-administration SA; external fluid administration EFA) between days. EFA refers to when someone else squirts water into the participant's mouth, whereas SA, the participant squirts water into their own mouth. The water bottle (WB) was kept equal distance from the mouth for both conditions. Participants weight (t-shirt and/or shorts only) and urine samples were collected prior to exercise. Participants then completed a 10-min warm-up. Participants had a 2-min fluid break before the exercise protocol (EP), which included a series of five 15-minute stations. Exercises provided aerobic and anaerobic demands, including hill jogging, push-ups, jumping jacks, ladder drills, and intermittent rest. After completing each station, participants received a 5-min fluid breaks where they drank *ad libitum*. Fluid variables and perceptual variables were collected during every fluid break. Following the final fluid break, participants provided a post-exercise weight and urine sample. The order of conditions and exercise stations were randomly assigned. Fluid variables assessed were volume consumed per fluid break (VC/FB), number of squirts per fluid break (#Sq/FB), squirt volume per fluid break (SqV/FB), total squirts (TSq), total volume consumed (TVC), and average volume per squirt (AV/Sq). Hydration status was assessed via urine specific gravity (USG), body mass loss (BML), sweat loss (SwL), and sweat rate (SwRt). Perceptual measures assessed include thirst and fullness. Repeated-measures ANOVA was used to analyze condition by time for VC/FB, #Sq/FB, SqV/FB, USG, thirst and fullness. A paired t-test was used for post-hoc analysis. Independent samples t-tests were used to analyze TSq, TVC, AV/Sq, BML, SwL, and SwRt. $P<0.05$ *a priori*

RESULTS: No significant interaction was indicated for VC/FB or SqV/FB ($p>0.05$). A significant interaction was noted for #Sq/FB ($p<0.05$). TSq between conditions did not indicate significance, however TVC and AV/Sq were significantly different ($p<0.05$). With no significant interaction for USG, participants arrived (SA=1.016±.009; EFA=1.019±.008) and remained (SA=1.019±.008; EFA=1.020±.007) hydrated throughout the EP. BML, SwL, SwRt, thirst and fullness also indicated no significant differences between conditions ($p>0.05$).

CONCLUSION: SA promoted more TVC likely due to greater VSq. Both conditions remained euhydrated, but EFA consumed less fluids. Euhydration may have been maintained because of regularly spaced fluid breaks and when regular fluid breaks are unavailable, EFA may result in more BML and hypohydration..

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CHAPTER 1

INTRODUCTION

Recent publicity over exertional heat stroke (EHS) fatalities in sports has fostered community and scientific engagement. Over the past fifty years, nearly 100 high school and collegiate athlete deaths have been attributed to complications from an EHS.[1] Awareness has helped support organizations focused on the education and prevention of EHS, as well as prompting further research investigations.

EHS develops when the body is unable to dissipate mounting thermal strain.[2-7] Previous studies have identified numerous factors that may attribute to the development of EHS, including exercising while in a hypohydrated state, cardiovascular fitness, degree of acclimatization, somatotype, sweat rate, sweat profile, equipment requirements, as well as duration and intensity of play.[3-5,7-15] Although there are many factors that may predispose an individual to develop an EHS, exercising in a hypohydrated state highly influences internal heat accumulation via hindrance on the thermoregulatory system. Adequate hydration is vital, as it allows for optimal heat exchange, thus slowing the rate of accumulation. [16,17] Studies in the past have evaluated the influence of fluid characteristics,[16-24] accessibility,[16,17,25-29] and hydration behaviors[3,5,12,13,16,17,26,30-33] in hopes of identifying the optimal environment to promote adequate fluid consumption.

Although any individual may develop an EHS, the prevalence of hydration issues among football players across all levels of play is quite high.[1,9,11-13,34-37] During observation of sidelines during football practices and games, one may observe individuals squirting water into athletes' mouths, instead of handing the athlete the water bottle (WB). This method of fluid administration is commonly utilized during football activity, yet to our knowledge has never been evaluated on its adequacy to hydrate athletes.

Research Question

What effect does fluid administration have on fluid consumption, hydration status, and perceptual measures during a bout of exercise?

Hypotheses

• Method of self-administration (SA) will promote participants to consume more fluids than external fluid administration (EFA).

• EFA will become more hypohydrated than SA over the course of the exercise protocol (EP).

• EFA will perceptually feel thirstier and less full compared with SA throughout the EP.

CHAPTER 2

REVIEW OF LITERATURE

This review of literature describes the components of hydration physiology, the mean to measure hydration, the pathophysiological consequences associated with exercise and hypohydration, as well as the incidence of hypohydration among football players. Fluid requirements, hydration practices and behaviors are also included in this review of literature.

Search Strategy

The MEDLINE, CINAHL, Pubmed, Pubmed Central, ERIC via EBSCOhost, and ScienceDirect databases were searched to obtain information using the following key words, singularly or in combination: heat, hydration, thermoregulation, fluid balance, thirst, performance, exercise, pathophysiology, football, collegiate athletes, prevalence, equipment, uniforms, thermal strain, perceived exertion, hydration measures, hydration behaviors, fluid consumption, fluid restriction, ad libitum, and sport drinks.

Hydration Physiology

Thermoregulation

As an active individual exercises, variations occur within the systems of the body to account for the physical demands that are required for performance.[4] For maintenance of exercise, there is an increase in metabolism. Metabolic activity produces heat as a by-product of chemical energy. As core temperature increases in an exercising individual, thermoreceptors located within the skin, muscles, and central nervous system send afferent signals to the thermoregulatory controls located within the anterior hypothalamus.[4,18,38] In turn, reciprocal efferent signals are enacted to provide alterations to systems to facilitate expulsion of the excess heat to the external environment.[38]

Within the blood, heat is transported via the circulatory system away from the working tissue. Vasculature in the peripheral circulation vasodilates due to the sympathetic nervous system responding to an increase in core body temperature.[4,18] Vasodilation of peripheral vessels enhances heat transfer from the core to the skin.[4,18] Heat may be transferred from the skin to the external environment by means of radiation, convection, and evaporation. Radiant heat loss is highly dependent on the environmental condition in which an individual exercises. If ambient temperature is less than skin temperature than heat will be transferred away from the body; however if the ambient temperature is greater than skin temperature, heat will be gained.[4,6,39] Heat can also be lost by means of convection, although this method of cooling is highly dependent on the degree of wind present.[4]

The optimal cooling mechanism, especially during exercise, is evaporation of sweat droplets produced by the eccrine glands.[40] Along with heat transfer to the skin for radiation and convection purposes, the increased skin temperature also helps to facilitate vaporization of sweat droplets.[4,18,41] With peripheral vasodilation, there is increase water availability to the eccrine glands to produce sweat.[4] Evaporative cooling has immense cooling capabilities, however it is plagued with a negative effect; water must be utilized for this mechanism to function optimally.[4,18]

Fluid Balance

As our body continues to lose water, various receptors responsive to changes in blood pressure, volume, and osmolality are stimulated to alert the brain there is a need for further alterations to conserve water to maintain central blood pressure.[4,6,38,39,41,42] Baroreceptors located within large vessels become activated in the presence of diminished blood volume.[4,18] The paraventricular and supraoptic nuclei of the hypothalamus receive neuronal inputs informing of the need to conserve water.[39,43] As such, anti-diuretic hormone (ADH) or arginine vasopressin (AVP), synthesized within these nuclei, are then released from the posterior pituitary gland to enact alterations on the glomerular filtration rate within the nephron of the kidneys, functioning to reabsorb water back into the central circulation.[18,43,44]

Along with the release of ADH, the renin-angiotensin-aldosterone system (RAAS) is activated in the presence of decreased blood volume.[43,44] Cells within the juxtaglomerular apparatus releases renin, which then cleaves the zymogen angiotensinogen.[44] Angiotensinogen is converted to angiotensin I, and with the interaction of angiotensin converting enzyme (ACE), angiotensin II is produced. Angiotensin II functions to vasoconstrict blood vessels, resulting in an increase in blood pressure, as well as causing the release of Aldosterone.[43,44] Synthesized in the zona glomerulosa located within the adrenal cortex, when released, Aldosterone promotes the reabsorption of sodium as its primary role.[43,44] Due to the nature of gradient that is set up with sodium reabsorption, water is prompted to follow. The conservation of water or electrolytes (sodium) by the kidneys can only reduce the rate of loss; it cannot restore a deficit.[18]

Thirst

Thirst is a component of the fluid regulatory mechanism that functions to maintain body fluid homeostasis. It is a subjective perception, which provides individuals the urge to drink.[18,43,45] Thirst mechanisms become activated upon a decrease in blood volume and/or an increase in plasma osmolality.[18,43,45] Activation of baroreceptors and osmoreceptors send afferent signals to the hypothalamus to initiate the cerebral mechanisms involved in thirst perception.[43]

Osmoreceptors are highly sensitive to plasma osmotic changes.[43] An important grouping of osmoreceptive neurons are located in the preoptic/hypothalamic region of the brain, particularly in both the organum vasculosum of the lamina terminalis (OVLT) and the subfornical organ (SFO).[42,43,46] The OVLT and the SFO are both circumventricular organs and are strongly interconnected with the median preoptic nucleus of the hypothalamus (MnPO).[43] Osmoreceptors located within the OVLT and SFO send neuronal input to the MnPO. Together these three structures comprise the AV3V region.[43,46]

As mentioned above in fluid balance, baroreceptors become activated due to changes in blood volume, and subsequent hormones are released to facilitate alterations in renal filtration, among other systemic interactions.[4,18,43,44] Aside from influences on filtration properties, these hormones (ADH/AVP and RAAS- angiotensin II and Aldosterone) also act as dipsogenic stimuli.[43,44] As discussed, ADH/AVP is synthesized within the supraoptic and paraventricular nuclei; some neurons in the OVLT project to these nuclei allowing for influence on the activity of ADH/AVP.[43,44,46] Angiotensin II also acts as a dipsogenic stimulus, binding to receptors on the SFO, MnPO and OVLT (AV3V region) to increase perception of thirst.[43,46]

Between hypovolemia and elevated plasma osmolality, thirst activation is much more sensitive to changes in osmolality rather than volume discrepancies.[18,43] Hypovolemic thirst activation is present only following a ten percent decrease in blood volume.[18] Sensitivity is less with hypovolemia, and it has been proposed that this lack of sensitivity is due to normally occurring daily variations in blood pressure.[18,46] Although hypertonicity provides a more sensitive neuronal input for thirst initiation, an increase of one to two percent in osmotic pressure of plasma must be present before thirst mechanisms can commence.[43] Another way to look at this, is an average threshold for initiation of thirst mechanisms is a water deficit of two percent body weight, keeping in mind that the threshold is individually dependent.[41] The major pitfall; thirst will not become active until water loss is equaled to or greater than two percent of body weight lost.[47] As such, an individual may not have the drive to drink even though they may be hypohydrated.[47]

Hydration Measures

The gold standard for assessing an individual's hydration status remains elusive.[48,49] Debate has occurred because the various methods utilized for assessing an individual's hydration status evaluates only a singular component involved in hydration measures.[48] As illustrated within the fluid balance and thirst sections, physiological interactions required for maintenance of euhydration is quite complex. To accurately evaluate the hydration status of an individual, measures should address the multiple components involved in fluid balance. [16,17,48,49]

Plasma Osmolality and Total Body Water (TBW)

To an extent, plasma osmolality coupled with total body water (TBW) measures is considered the gold standard for assessing hydration.[48,49] However, this gold standard is selectively applicable.[48] In laboratory studies where individual's body fluids are stable and equilibrated, plasma osmolality and TBW are considered sound measurements to provide the most accurate evaluation of hydration status.[48] These measures are not accepted universally as the gold standard due to the lack of practicality and ease of use.[48,49] When controls are not in place to allow fluids to equilibrate, such as in athletics where there is immense physiological strain, coupled with fluids being continually lost and replaced at varying degrees, other measures utilized to assess hydration status should be employed. [16,17,48,49]

Body Mass Loss

Monitoring body mass changes prior to and upon completion of an exercise bout, has demonstrated the most accurate measure of a change in hydration status in real time.[48] To provide an accurate baseline for comparison, a euhydrated average daily weight should be determined prior to competition. Accompanying changes in body mass, at least one measure of urine analysis should be utilized to enhance agreement of an individual's hydration status.[16,17,48,49]

Urine Indices

Urine specific gravity (USG) and urine osmolality (U_{Osm}) are both means of measuring urine concentrations. As discussed in the fluid regulatory section, chemicals are released in the body to enact alterations in response to either volume discrepancies and/or osmotic imbalances.[4] These chemicals directly act of the kidneys and as a result alter the composition of urine being excreted from the body.[44]

Urine specific gravity compares the density of urine with water.[50] The upper limit for euhydration is ($1.020\ g \bullet mL^{-1}$).[16,17,49] This method is relatively inexpensive and requires minimal technical expertise, making it a viable option to couple with body mass changes to enhance accuracy for assessing an individual's hydration status.[49] Urine osmolality is the most effective method for measuring the total solute concentration of urine, however an Osmometer is quite expensive and requires a relatively high level of technical expertise to use.[50] The upper limit for euhydration is ($700\ mOsmol \bullet kg^{1}$). [16,17,49]

Perceptual Measures: Thirst and Exertion

The previous measures mentioned above evaluate hydration status on a quantitative basis. A quasi-qualitative assessment of hydration status can include perceived values for thirst and exertion.[51] Thirst is a subjective stimulus related to alterations in body fluids and/or osmotic gradients.[43] With thirst being directly related to an individual's hydration status, measures indicating thirst can be utilized in combination with quantitative measures to obtain an assessment of an individual's hydration status. Accompanying a thirst scale, a rated exertion scale can be utilized to address feelings of fatigue. An individual whom is hypohydrated experiences fatigue earlier compared to an individual whom is euhydrated; provided all other variables are consistent between the two.[4] Rated exertion has been shown to be a good subjective measure for assessing hydration level, when in combination with quantitative measures.[49,51]

Volume Consumed (VC)

The volume of fluid being consumed (VC) during exercise should be monitored to better understand hydration behaviors. Knowledge of VC helps to identify adequate or insufficient fluid consumption during activity. By monitoring VC, hydration plans can be developed for individuals with inadequate fluid consumption behaviors during activity. Promoting rehydration will decrease the chances for individuals to become more hypohydration as well as the potential for developing an EHI. [16]

In an article by Cheuvront and Sawka,[49] a Venn Diagram was formulated to represent the three means of measuring hydration status which are considered the simplest and most practical measures to use (WUT-Weight, Urine, and Thirst). As previously mentioned, combining another measure of hydration with body mass changes (weight) improves the likelihood for obtaining an accurate hydration status.[16,49] As highlighted in Cheuvront and Sawka's diagram, the combination of the three measures further improves the likelihood of an accurate assessment of an individual's hydration status.[49]

Exercise Pathophysiology

Along with a decreased ability to perform optimally when hypohydrated, serious health issues can develop if fluids are not consumed to off-set fluid lost.[3-5,7,17,52,53] Conditions that are minor but can develop due to exercising in a hypohydrated state include heat cramps and heat syncope.[4,5,7,52] Although some minor heat illnesses can present, other more serious heat illnesses are of greater concern, including exertional heat exhaustion (EHE) and exertional heat stroke (EHS).

Heat Cramps

Heat cramps, better described as exercise associated muscle cramps, develop during or following intense exercise, and presents as acute, painful, involuntary singular or multi muscular contractions.[3-5] The proposed etiology of heat cramps include fluid imbalances (hypohydration), electrolyte imbalances, neuromuscular fatigue, or any combination of these factors.[4,5]

Heat Syncope

Heat syncope, also referred to as orthostatic dizziness, occurs when an individual is exposed to high ambient temperatures and results in collapse.[5] Heat syncope often occurs following standing erect for a long duration of time, immediately after activity, or following a rapid change from a seated or laying position to standing upright.[4,5] Collapse occurs due to insufficient blood being delivered to the brain.[4] A diminished venous return can result from peripheral vasodilation, pooling of blood in the extremities, hypohydration, and/or cerebral ischemia.[4,5] Both, heat cramps and heat syncope can be treated successfully with replacement of lost fluids and adequate rest.[4]

Exertional Heat Exhaustion (EHE)

EHE develops due to a lack of sufficient blood volume (water) circulating throughout the body.[3-5] EHE is defined as the inability to continue work or exercise in the heat with any combination of heavy sweating, hypohydration, sodium loss, and energy depletion. [3-5,7] Exercising in a hypohydrated state places the body in a conundrum. Skin and muscles are requiring circulating blood to facilitate the cooling mechanism and provide nutrients for sustained activity.[4,6,39] The body recognizes the decrease in blood volume and need for maintaining central circulation, as such, limiting the supply to muscles and skin.[4,6,53] As a result of the physical demands placed on the body coupled with increased core temperature, the body is unable to meet all requirements. As a postulated safety mechanism, the body collapses to prevent any further stress to the body.[3]

Common signs and symptoms associated with EHE include pallor, persistent muscle cramps, weakness, fainting, dizziness, headache, hyperventilation, nausea, decreased urine output, and with a core body temperature generally ranging between 36°C and 40°C.[5] Treatment for EHE includes removal from activity, placed in a cool environment, with ample amounts of fluids provided.[2-5,7,16,17,53]

Exertional Heat Stroke (EHS)

The most severe of all potential heat illnesses, exertional heat stroke (EHS), is the result of a core temperature rising above the critical temperature of 40°C.[3,5] EHS is associated with central nervous system alterations and multiple organ failure if allowed to progress.[2-5,7,53] EHS develops merely from an accumulation of internal heat that is unable to be released from the body.[3-5] Unlike the other mentioned heat illnesses, exertional heat stroke is life threatening. Unless early recognition and proper treatment is implemented, mortality rate for EHS is high.[3]

Treating exertional heat stroke, although rehydration is important, primarily consists of immediate ice water immersion.[3,4,54]

Factors Increasing Risk of EHI

Any individual exercising in a hypohydrated state can be susceptible to developing an exertional heat illness (EHI).[4] With that being said, certain variables or characteristics can influence the likelihood for developing such heat illnesses. Of the varying factors, the level of fitness an individual is in and the degree of acclimatization to current exercising condition, are widely accepted as the primary factors leading to EHI.[3-5,34]

Cardiovascular Fitness

Untrained individuals are more susceptible to EHI due to an insufficient cardiopulmonary system for exchange of nutrients and expulsion of internal heat.[3-5] As an individual exercises and VO_2max improves, the ability of that individual to withstand heat stress improves due to an improvement in nutrient delivery and circulatory cooling mechanisms.[5]

Acclimatization

An individual that lacks acclimatization to the climate in which they are exercising, increases their risk for developing an EHI.[3-5,34] Such as, when an individual is exercising in a hot environment, a large amount of internal heat is produced. In an unacclimatized individual, cooling mechanisms are not as sensitive nor as efficient, as is in an individual whom is heat acclimatized.[4] Acclimatization functions to enhance heat dissipation and reduce cardiovascular strain; less physiological and thermal strain placed on the body results in a less chance for developing an EHI, as well as decreasing the likelihood for performance deficits.[4]

Body Composition

Obese individuals are at an increased risk because they are less efficient and have a greater metabolic heat production during exercise.[5,35] Individuals with a greater body surface area may have larger sweat glands or additional sweat glands, either of which facilitates the cooling mechanisms.[35] However, an increase in sweat loss results in an increased rate of dehydration. Unless fluids are replaced to off-set loss, thermal strain is inevitable, and as such increasing the chances for an EHI.[4]

Sweat Profile

A 'heavy sweater' or 'salty sweater' can lose significant amounts of both water and sodium during activity.[5] Heavy sweaters are at an increased risk because they are continually losing large amounts of fluids, increasing the likelihood of hypohydration.[4,5,11,13] Hypohydration places vast physiological strain on the body, particular hindrance on the circulatory system.[4,6] Inability to cool effectively eventually will result in an exertional heat illness.[3-5,7,16] Salty sweaters also experience similar issues with hypohydration effects on systemic function, and specifically are at an increased risk for developing heat cramps. In a study by Stofan et al,[55] football players with a history of heat cramps lost more total sodium, were more hypohydrated, and had higher sweat rates compared to individuals with no previous history of heat cramps. Individuals who are salty sweaters should also take care to rehydrate with electrolyte solutions rather than strictly water. If improper rehydration occurs (i.e. water), there is a potential for development of dilutional hypoatremia.[41]

Equipment Considerations

Equipment such as jerseys, pants, helmets, and pads all function to inhibit evaporative, convective, and radiant heat loss.[3-5,10,11,35,56] Hindrance on cooling mechanisms allows internal thermal strain to continue to increase towards the critical temperature when physiological dysfunction occurs.[4] If the body is unable to dissipate the internal heat, exertional heat illnesses may develop.

Performance Effects

Through decades of extensive research on the physiology and subsequent pathophysiology of hypohydration, it is well understood the vast physiological and performance alterations hypohydration plays on the human body.[2-6,39,40,47,53,57-60] Without sufficient water, an exercising individual would continue to accumulate heat internally, pushing their core temperature further away from the thermoneutral range. With a rising core temperature, systemic bodily malfunction ensues.[4,6,57,59,61] The external manifestation of these malfunctions is a hindrance on performance and physiological strain.

Cardiopulmonary System

As an individual exercises, heat produced is expelled from the body by transport of blood to the peripheral circulation as previously discussed within the thermoregulatory section.[4,6,18,39] Due to the continual loss of water as a means to cool the body, blood volume decreases. A decrease in blood volume causes the cardiovascular system to work on overdrive (increased heart rate) to maintain cardiac output.[4,6,40] As a result, maximum cardiac output is reached at a lower intensity.[4] VO_2max is also decreased due to the diminished capacity of the cardiovascular and circulatory system to provide adequate transport and exchange of oxygen and other nutrients, as well as removal of waste.[4]

Musculoskeletal System

Decreased blood circulating to working muscles results in a diminished availability of nutrients and the capacity to remove waste; both of which are essential for continued exercise performance.[4] Decreased circulation also functions to hinder the body's ability to remove heat from the working muscles.[4,17,57] These three factors: decreased nutrient delivery, waste removal and heat extraction all function to limit muscular endurance, power, and strength.[4,6,17,40,53,62,63]

Central Nervous System

Nervous tissue among all other tissues of the body is the most sensitive to thermal changes.[4] Alterations to the brains electrical activity and decreases in cerebral blood flow results in chemical reactions going askew, leading to central fatigue.[57,59] External manifestation presents as deficits in cognition and balance.[40,57,59-61,64] Cognitive alterations that result in diminished athletic performance include response time, judgment, concentration, decision-making, and short-term memory.[52,57,59-61] Postural stability and proprioception have been noted as balance deficits demonstrated in hypohydrated individuals.[40,64]

Incidence of Hypohydration in Football

Hydration is vital for optimal health and performance while exercising. Unfortunately, due to the nature of the sport, the prevalence of hydration issues among football players across all levels of play is quite high.[1,9,11-13,34-36,65] In an epidemiological study conducted by Huffman et al.[36], rare injuries/conditions (RICs) sustained by American high school athletes were observed over the 2005-2006 and 2006-2007 school years. One hundred high schools located throughout the United States partook in this study, with nine sports examined at each (football, boys' soccer, girls' soccer, volleyball, boys' basketball, girls' basketball, wrestling, baseball, and softball). In this study, rare injuries/conditions included eye injuries, dental injuries, neck/cervical spine injuries, and dehydration/heat illnesses. Results indicated a rate of 9.14 RICs per 100,000 athlete-exposures, suggesting an estimated 84,223 RICs were sustained nationally during the two years studied.[36] Although this is a seemingly low rate for injury, rare injuries/conditions tend to be more serious in nature and potentially more costly due to accruing further medical treatment.[36]

Dehydration/heat illnesses was the second most common diagnosis (18.7%, n=60) in the high school athletes observed.[36] Comparing the rate of injury between the different sports, prevalence was the greatest among football players, particularly involving neck/cervical spine injuries and dehydration/heat illnesses.[36] Interestingly, the dehydration/heat illness analysis from this investigation suggested there is an eleven times greater rate for football players developing hydration issues compared with all other sports combined.[36]

In 2007, an epidemiological study was published evaluating injuries sustained by collegiate football players.[34] Sixteen years (1988-2004) of data was obtained from the NCAA Injury Surveillance System (ISS) to evaluate type and occurrence rate related to three different periods within a football season (fall practice, fall games, and spring practice). Analysis from the data collected identified fall games as the greatest rate of injury, occurring nine times more than compared with practice injury rates.[34] Heat/hydration related issues occurred most often during fall practices, accounting for 3.9% (n=1632) of all injuries sustained during the studied period.[34] Heat illnesses were not reported to the NCAA ISS if they did not result in loss of playing time. With that being said, although heat/hydration issues makes up only a small percentage of the injuries experienced by football players, these issues, unlike a good proportion of the other injuries commonly sustained, if allowed to progress, pose a serious risk to an athlete's health.[34,36]

Over the past fifty year, nearly 100 high school and collegiate athletes have lost their lives due to complications resulting from an exertional heat stroke (EHS).[1] Although there are many factors that can cause an individual to develop an EHS, adequate hydration is vital, as it allows for optimal heat exchange, thus slowing the rate of internal heat accumulation.[16,17] Most of the 100 unfortunate EHS deaths occurred in the first two to four days of preseason football practice.[1] This trend may be attributed to the degree of acclimatization an athlete has to the conditions in which the exercise is occurring.[1,4] As mentioned within the factors influencing prevalence section, degree of acclimatization is a strong determinate in the likelihood for developing an exertional heat illness.[3,5]

In another epidemiological study, Cooper et al[9] evaluated five division I football programs from the southeastern aspect of the United States, to identify trends in exertional heat illnesses (EHIs) experienced by collegiate football players. Data was collected for three months, August through October in 2003. During the three-month period, 139 EHIs were reported.[9] Of the 139 EHIs, 122 (88%) occurred in the first month (August) of training.[9] The remaining 17 cases occurred in September (12%), and no EHIs were reported in October.[9] Unlike previous studies mentioned,[34,36] consideration for reporting heat illnesses in this study included injuries which did not require loss of playing time (i.e. heat cramps). As such, results from this study indicate a much higher rate of injury compared with other previously mentioned studies.[9]

Regardless on inclusion criteria, hydration issues are of real concern for football players and Athletic Trainers alike. Due to the culture of football, several variables place football players at a greater risk for developing heat and hydration issues.[1,11-13,26,30,35,37,56,65] Factors extrinsic to the athlete include, environmental conditions an athlete exercises in, clothing/equipment worn, as well as the duration and intensity of practice/games.[3,5,8,11,12,15,35,37,66] Intrinsically driven variables include level of acclimatization, aerobic fitness, somatotype (percentage of body fat, body mass and surface area to mass ratio), as well as the hydration behaviors of athletes.[3,5,12,35,37,65]

Hypohydration in Football: Extrinsic Factors

Ambient Temperature, Wind Speed, and Humidity

The environmental condition an athlete exercises in will highly influence the degree of stress placed on the body.[4] When individuals exercise in the heat, cooling mechanisms and heat transfer properties are hampered. High ambient temperatures limit the capacity of radiant heat exchange.[4] In cases where the air temperature is greater than an athlete's skin temperature, heat will be gained rather than lost.[4,8,66] Wind is another factor determining how effective the body's thermoregulatory system functions in transferring heat to the external environment.[67] Wind utilizes convective heat transfer properties, promoting heat transfer by providing a greater temperature gradient between an athlete's skin and the ambient air.[4,67] When the air is stagnant, it eventually heats to meet skin temperature; this in turn, limits the capacity of convective and radiant heat loss.[4,67] The humidity in the air also highly influences the cooling capacity by limiting the necessity for sweat droplets to vaporize into the air.[67] Sweat production will do little to cool exercising individuals if it cannot evaporate off the skin.

A majority of heat/hydration illnesses occur within the first month or so of the football season.[1,9,34] For most of the United States, the month of August is the hottest and most humid.[12,56] The majority of football programs start preseason practice in early August, exposing athletes to potentially dangerous environmental practice conditions.[12] Although there are many other factors that contribute to the development of an EHI, environmental characteristics highly influences predisposition.[3,4]

Clothing/Equipment Considerations

Protective equipment and uniforms worn by football players has gained recent attention by investigators[8,15,66,67], aiming their focus towards evaluating factors contributing to the thermal strain experienced by athletes while playing football. Two key factors associated with the equipment and uniforms worn, have been identified as contributing to an increased likelihood for football players developing a heat/hydration issue.[8] The weight and bulk of the protective equipment worn results in a great workload required for performing exercise tasks.[8,66] The greater the workload, the more heat is produced because of increased metabolic activity, resulting in increased stress placed on the body .[4] Additionally, protective equipment and uniforms create a barrier for heat transfer, thus limiting the thermoregulatory system function.[5,8,15] With each layer of clothing worn, layers of air pockets form between each layer and on the outside of the exterior layer.[67] When stagnant air is allowed to warm to skin temperature, heat transfer via radiation and convection are negated.[67] Evaporative mechanisms are also hampered by clothing barriers as it limits the opportunity for vaporization of sweat droplet, due to the increased water vapor content of the trapped air.[67] Both of these key factors function to increase stress placed on the body and limit the ability of the thermoregulatory system to expel the heat produced during football play.

Duration and Intensity of Play

The duration and intensity level of exercise has been well documented as contributing factors in the development of a heat and/or hydration issue.[3-5,16,17] Football players are at an increased risk due to the length and frequency of football sessions, as well as the dynamic intermittent work intensity required.[12,35,65,68]

The likelihood for developing a water and electrolyte deficit via sweating increases as the length of football practices or games are extended.[16,17] Longer practices provide the opportunity for more physical work to be performed, and greater exposure to potentially hazardous environmental conditions, both of which promotes internal heat accumulation. Mounting internal heat must be expelled for preservation of bodily functions; this however is hindered by fluid deficits.[4]

The intensity level of exercise being performed will also highly influence the amount of stress placed on the body.[4] As intensity level increases, energy requirements must be met by increasing metabolic activity. Higher rates of metabolism results in a greater amount of internal heat produced. Extensively discussed in preceding sections, mounting internal heat is detrimental to bodily functions.[4] To facilitate expulsion, water is used as the vehicle for heat transfer to the external environment. As the body utilizes its water stores, a deficit occurs, leading towards a state of hypohydration. Rigors of intermittent intense exercise seen in football, coupled with rather lengthy training sessions, further promotes the chances for football players to become dehydrated.[68]

Hypohydration in Football: Intrinsic Factors

Level of Acclimatization

Research has well identified the physiological alterations that occur during exposure to challenging environmental conditions.[4] Adequate acclimatization to the current exercising condition is one of the most important preventative measures an athlete can take against issues with thermal strain and performance detriments.[4]

For optimal acclimatization, an athlete should exercise in the current conditions at a gradual pace over ten to fourteen consecutive days.[4,12] This time span allows all adaptations to occur, providing the most favorable physiological environment for exercising. Benefits from acclimatization include decreased core body temperature, decreased heart rate, and an increased sweat rate, sweat sensitivity, plasma volume, and stroke volume.[3-5,12] These adaptations function to promote heat transfer and decrease perceptual feelings of exertion, ultimately allowing athletes to exercise longer while limiting risks for heat/hydration issues.[3-5,12]

Athletes who are not acclimatized place both their health and their athletic performance at risk. This is an ever-present issue with football players. Preseason is often the most rigorous and physically demanding period during the entire football season, with often the most challenging environmental conditions.[12,56] If football players are not physiologically prepared to perform in these conditions, potential for health issues ensue. This is ever so apparent by the trends identified within previous epidemiological studies.[1,9,34] As highlighted within the incidence of hypohydration in football, most of the 100 football athletes cited as dying due to EHS complications, occurred within the first two to four days of preseason practice.[1]

Within the past couple of years, legislation was set in place by the NCAA outlining acclimatization guidelines for collegiate football programs.[12] These guidelines entail a five-day progression of practices involving duration, frequency, and equipment worn.[12] Yeargin and colleagues[12] evaluated the new NCAA guidelines in an observational study of a Division I football team. Physiological, psychological, fluid balance, anthropometric, and nutritional variables were utilized to evaluate the effect of these new guidelines. Results from this investigation indicated that football players experienced acclimatization gradually and heat tolerance improved. Although these guidelines are now in place for the collegiate football population, there is still currently no set-forth regulation on high school football programs.

Aerobic Fitness

The degree of aerobic fitness an individual is in will influence how they will respond to exercising in a challenging environmental condition.[3-5] Often aerobic fitness is experienced by means of VO_{2max}, or maximal oxygen consumption. The more in shape an individual is, the higher their VO_{2max} will be, indicating adaptations within the body to facilitate transport and exchange of oxygen and other nutrients, as well as removal of waste products.[3-5]

With the nature of football requiring intermittent activity, rather than continuous, football players tend to have rather low VO_{2max} when compared to other athletes in different sports.[37,68] Maximal oxygen consumption, or VO_{2max} refers to the maximum capacity of an individual's cardiovascular and circulatory system to transport and exchange oxygen and other nutrients during exercise.[4] Athletes with poor aerobic fitness will be hindered in this ability to provide adequate nutrients to the working muscle, thus limiting their ability to sustain activity.[3-5]

Somatotype

The physical build of an individual will influence how their body responds to challenging environments.[5] Due to the physique required for the sport, football players are placed at a greater risk for heat and hydration issues.[35]

Unlike most sports, where players have fairly homeogenic physical characteristics, football players present more heterogenic characteristics, mainly due to the vast physical demands dependant on the position played.[35] In a study by Godek et al.,[35] a sample of professional football players were evaluated on sweat rates and fluid turnover based on their position. Results from this study indicated, interior lineman had greater body mass, higher sweat rates, lost larger volumes of sweat, and consumed more fluid. Significant correlations were identified between sweat rate and body mass, as well as between sweat rate and body surface area.

Body mass can be interpreted as the amount of weight an individual must overcome to produce movement. The greater the body mass of an individual, the greater the amount of work is required to perform a set task.[5,35] To meet such requirements, metabolic activity is increased.

Increased metabolic activity results in increased internal heat production.[4] To compensate, sweat rates are increased to promote heat expulsion.[4,35] Fluid consumption must occur to counter sweat loss, otherwise hypohydration and heat issues are of concern.

Surface area to body mass ratio also influences thermoregulatory efficiency.[5] Individuals with large surface areas (i.e. offensive lineman) are afforded the opportunity for greater heat dissipation by means of more, and/or larger-diameter sweat glands.[35] An increased sweating ability is advantageous for cooling mechanisms; however, it also promotes greater fluid lost.[4,5] Unless ample fluids are consumed to replace these losses, hypohydration and heat issues will ensue.

On the other end of the spectrum, athletes with large lean muscle mass tend to have a proportionally small surface area.[35] This ratio sets up for large heat production capabilities via powerful muscle contraction, however is plagued by limited opportunity to rid the accumulating internal heat.[35] This type of physique is often seen in the positional players for corner backs and wide receivers.[35]

Fluid Replacement

In the past decade, the NATA[16] and the ACSM[17] have published position statements regarding exercise and fluid replacement for athletes. Within each position statement, guidelines are presented detailing appropriate hydration methods prior to, during, and following the completion of exercise.

Pre Exercise

For optimal hydration prior to an event, a well-balanced diet and fluids should be consumed twenty-four hours prior to competition.[16,17] Exercising individuals should consume 400-600 mL of fluid (14-20 fl oz) two to four hours before exercising, and consume another 200-

300 mL of fluid (7-10 fl oz) ten to twenty minutes just prior to commencement of exercise.[16,17] Consuming fluids hours prior to competition allows the body adequate time to excrete any excess fluid that was consumed. [16,17] When large volumes of fluid (i.e. water) are consumed in a short period, there is an immediate change in fluid balance.[16,17] A means to address these changes, the body produces dilute urine.[17] Speedy consumption is disadvantageous to an athlete attempting to hydrate because fluids are too quickly expelled before intracellular and extracellular fluid compartments are able to equilibrate.[16,17]

During Exercise

Determining the appropriate amount of fluid to consume while exercising is highly individualized.[16,17] Factors that are particular to the individual (intrinsic) and factors related to the type of exercise being performed (extrinsic) cumulatively determine the appropriate amount of fluid an individual should consume during exercise.[16,17] Generally speaking, fluid consumption should match (or closely match) sweat rate.[16,17] An easy way an athlete can monitor their sweat rate is comparison of pre-exercise weight to post-exercise weight. For every kilogram lost, one liter of fluid should be consumed to match the water deficit.[69]

As discussed within the NATA position statement[16], there are two main purposes to hydrating during exercise; (1) to decrease rate of hyperthermia and (2) to maintain athletic performance. Although there may be other factors that can cause an individual to reach hyperthermic temperatures, adequate hydration facilitates the thermoregulatory system to function to its peak potential.[4,16] Thus, allowing the body to use its resources to expel mounting internal heat. Maintaining athletic performance is highly dependent on adequate hydration.[4] As an individual becomes more and more dehydrated, the circulatory and thermoregulatory systems progressively fails to counteract the stressors being applied to the body.[4] With failing mechanisms, performance deficits ensue, as well as the aforementioned hyperthermic concerns.[16] It is clear that hydration during exercise is quite important and functions to provide an environment for optimal performance while limiting health concerns.

Post Exercise

Following completion of exercise, rehydration should be geared towards the difference of weight lost during exercise.[16,17] The duration an individual has to rehydrate will affect rehydration methods. For optimal rehydration, at least twelve hours should elapse prior to the next bout of exercise.[17] With a longer duration, individuals are instructed to consume fluids at a slow pace and to maintain a well-balanced diet.[16,17] When rehydration must occur within less than twelve hours, a more aggressive hydration protocol is warranted.[17] An excess amount of fluid beyond loss during exercise has been recommended.[16,17] With a shorter duration to rehydrate, pace of consumption naturally increases (when consuming the appropriate amount of fluids). As discussed earlier, with large volumes of fluid being consumed in a short period, the body responds to the immediate alteration in fluid volume by prompting the kidneys to expel the excess water via urine.[16,17] For rapid rehydration, individuals should consume roughly one and a half liters of fluid for every kilogram lost (~ 6 cups or 50 fl oz).[17] If pounds are a better measurement for athletes, for every pound lost, recovery fluid consumption should match 750 milliliters (~ 3 cups or 25 fl oz). The composition of fluid being consumed is an important component for optimal rehydration, however further detail regarding selection of fluid type will be discussed in detail in the proceeding section.

Factors in Determining Water vs. Sport Drinks

Determining the appropriate type of fluid to consume is dependent on several factors, including timing of hydration (pre, during, or following exercise), duration of exercise, sweat profile, and type of hypohydration.[16,17,52]

Pre Exercise

When considering fluid composition for pre-exercise consumption, timing of last exercise bout will highly influence the proceeding pre-exercise hydration method. Provided twelve to twenty-four hours has elapsed since the last exercise bout, adequate hydration should be easily reached by maintaining a well-balanced food and fluid diet.[16,17,52] These guidelines may not apply to individuals whom have suffered severe hypohydration during the previous exercise bout.[16,17] As such, severe hypohydrated individuals should follow a more aggressive hydration protocol, indicating advantages for consuming a carbohydrate-electrolyte beverage (or sport drink).[16,17] A sports drink facilitates fluid retention and enhances thirst mechanisms by altering the osmotic gradient to promote water reabsorption and a continued drive to consume more fluids.[16,17] Similarly, sport drinks are also advantageous when a proceeding exercise bout is less than twelve hours apart.[16,17]

During Exercise

Duration of an exercise bout will highly influence the type of beverage that is optimal for rehydration.[17] Research has indicated exercise lasting less than fifty minutes in a thermoneutral environment produces no benefit when consuming differing fluid compositions.[42] Other factors involved may influence the need for a sport drink beverage (i.e. salty sweaters) to be consumed during an exercise bout lasting less than fifty minutes, however generally speaking, water is sufficient for a rehydration fluid under these conditions.[42] When exercise lasts more than fifty minutes, the likelihood for electrolyte and water loss via sweat increases; thus, highlighting the need for replacing fluid and electrolyte deficits.[16,17]

Aside from exercise duration, the intensity of an exercise will also influence the appropriate fluid to consume for optimal rehydration.[52] As intensity increases, more work is placed on the body. To compensate for the increased workload, metabolism increases, resulting in mounting internal heat.[4] To dissipate the heat, sweat rate increases, thus leading to greater amounts of water and electrolytes being lost from the body.[4] The greater the intensity of a workout, the greater the need is to replace lost electrolytes with accompanying fluid deficits, as illustrated by the increase in sweat production to counter mounting internal heat.[4] In these situations, it is clear that consumption of a sport drink is advantageous over water in rehydrating an athlete.

Post Exercise

For determining fluid composition following an exercise bout, two factors should be taking into consideration. First, the time in which the athlete has until the next exercise bout, and second, the degree of hypohydration an individual has developed.[16] As discussed within the pre exercise section, with periods greater than twelve hours between exercise bouts, maintaining a nutritionally balanced diet should replace lost fluids and electrolytes adequately.[16,17] When less than twelve hours are available for rehydration, a sports beverage is a better choice for fluid consumption because the electrolytes and carbohydrates facilitates fluid and electrolyte reabsorption as well as enhancing the thirst mechanism, thus promoting further fluid consumption.[16,17] Severely hypohydrated individuals require a more aggressive rehydration plan post exercise to account for the large water and electrolyte deficits, indicating benefit to consumption of sport drinks to enhance rehydration mechanisms.[16,17]

Sweat Profile

The composition of sweat that is produced by individuals while exercising will influence the type of fluid needed for proper rehydration. 'Salty sweaters' will loss an excess amount of the body's electrolyte stores (particularly sodium) with durations of perfuse sweating during exercise.[17] Proportionally, when sodium loss exceeds water loss, an individual progresses towards a state of hypotonic hypohydration.[41] Adequate rehydration requires individuals to consume fluids that contain electrolytes, to counter the body's deficit resultant of sweating.[17]

Strictly consuming water for rehydration would be inappropriate for salty sweaters exercising for long durations. By not addressing the electrolyte deficits, blood osmolality continues to drop, further progressing an individual towards developing a potentially fatal hydration illness; dilutional hypoatremia.[17] Dilutional hypoatremia develops resulting from deficits in pertinent ions within the blood to produce an osmotic gradient (i.e. sodium, potassium, and chloride).[5,17,44] Without an adequate osmotic pressure, necessary gradients in the body are altered, resulting in physiological disarray.[44] Symptoms associated with hypoatremia include severe headaches, vomiting, swelling of the hands and feet, restlessness, fatigue, confusion/disorientation (encephalopathy), and wheezy breathing (pulmonary edema).[5,17] Symptoms progress rapidly as osmotic pressure continues to drop, and the return to a homeostatic environment takes longer the lower the osmotic gradient is allowed to reach.[17] Thus, it is clear the necessity to identify and monitor individuals whom may be susceptible to this illness and provide the appropriate composition of fluid to properly rehydrate those athletes.

Type of Hypohydration

Athletes most commonly suffer from hypovolemic-hypertonic hypohydration.[45] When volume of body fluid is of issue, consumption of water will suffice to counter volume deficits.[41,45] However, in cases where electrolyte imbalances are of issue (such as seen with salty sweaters), a sport drink would be more appropriate.[16,17] In these instances, composition of the fluid being consumed is vital for regaining euhydration.[17,41,45]

Factors Influencing Hydration Practices

Palatability

Palatability of fluids is an important factor that will influence how much and/or how often an athlete will consume fluids.[16-20,22-24,29,70] The palatability or tastiness of beverages has been investigated for many years.[22-24] Through those investigations, a variety of factors have been identified as strong determinates in the quantity of fluid consumed. Of the various factors investigated, two in particular have been indicated through numerous studies as highly influencing fluid intake.

The temperature of a fluid highly influences fluid consumption.[18-20,22-24] In a field study conducted in the late 40s, Rothstein et al.[24] evaluated the fluid intake of soldiers after walking for two hours in a hot environment (39°C). Participants in this study were separated into two groups, one receiving cooled water (13°C) and the other receiving warm water (28°C). Results from this investigation indicated the cooled water group replaced lost fluids by 87%, whereas the warm water group only replaced 75%. In a later investigation, Hubbard et al[22] evaluated the impact of temperature on fluid intake in a laboratory setting, having twenty-nine healthy males march on a treadmill for 14.5 km in 40°C heat. The participants were randomly assigned to one of three groups (tap water, iodine-treated tap water, or iodine-treated flavored tap water) and offered different fluid temperatures during the two trials (trial 1=40°C, trial 2=15°C). Results from this investigation indicated temperature had a significant effect on fluid consumption, identifying the cooled fluid trials had an 87% increase in fluid intake over the warm water trials. A few years following Hubbard's work, a study by Szlyk et al[19]investigated temperature influences on fluid intake with intermittent activity (30 min treadmill walking: 30 min rest, for 6 hours) and indentified similar results.

In an investigation to identify the optimal fluid temperature for prompting individuals to drink, Boulze et al[23] evaluated 140 mountain patrol guards and 260 healthy volunteers. Both populations we exposed to conditions promoting dehydration prior to fluid consumption. Participants were divided into groups of twenty; each group was assigned to a different fluid temperature, ranging from 0°C-50°C in 5°C increments. Results from this investigation indicated fluids are consumed in greatest quantity when they are 15°C. These results mirror the current recommendations set forth by the NATA[16] and ACSM[17] position stands regarding fluid replacement for athletes.

The flavor of a beverage has also been indicated as highly influencing an individual's fluid consumption.[16,17,19-22] Rolls and Rolls in 1982[21] evaluated the volume of fluid consumed by participants within three different fluid groups. Participants were instructed to consume three drinks successively, and were given a ten-minute period to do so. Results from this investigation indicated individuals consumed 22% more fluids when offered a variety of flavors compared to one flavor, and 99% more fluids were consumed in the one flavor trial compared with no flavor (water).

In Szlyk et al.[19] previously mentioned study; flavor was also evaluated for its influence on fluid consumption. Participants were grouped based on their drinking habits during the exercise protocol. Individuals that stayed within 2% of body mass loss were considered 'drinkers' and those who experienced greater deficits were considered 'reluctant drinkers'. Interesting, the 'drinkers' group did not experience any marked difference in fluid consumption relating to flavoring.[19] For these individuals, temperature seemed to be the determinate of fluid consumption. However, in the 'reluctant drinkers' group, flavoring did play a role. When warm water was flavored, consumption increased by 79% compared to warm non-flavored water. Temperature and flavoring effects indicated an additive effect, representing the greatest volume of fluids consumed.[19] These findings are in accordance with other investigations indicating temperature and flavor of a beverage is advantageous for fluid consumption. [16,17,20,22]

Fluid Availability

As highlighted within the NATA[16] position stand on fluid replacement for athletes, athletes generally do not rehydrate to pre-exercise levels during exercise. Reasons attributed to these findings include personal choice, accessibility, circumstance of competition and/or personnel, or any combination of these factors.[16]

In a study conducted by Engell et al.,[28] accessibility of water was manipulated to evaluate fluid intake. During an ad libitum meal, water bottles were placed in three locations (on the dining table, ~ 20ft from the table, and ~40 ft from the table). Results from this investigation indicated fluid intake was greatest when fluids were positioned on the table (444 ± 260 g) compared to 20 ft away (197 ±100 g) and 40 ft away (187 ± 155 g).

In a study by Iuliano et al.,[27] fluid accessibility was evaluated in relation to circumstance of sport in 32 elite junior athletes. A simulated duathlon was utilized for this study and consisted of a sequence of running, cycling, and running. The results from this study indicated athletes consumed more fluids during the cycling portion of the duathlon, compared with either trials of running. This was attributed to the circumstance of the sport. Attempting to consume fluids while competitively running poses difficulty for some as well as potential performance limitations, thus deterring athletes from hydrating during those periods.

In 2010, Yeargin et al.[26] evaluated the thermoregulatory responses and hydration practices of high school football players during their preseason practices. In a heat and hydration knowledge and habits questionnaire administered to each participant, results indicated 96% reported only consuming fluids during structured water breaks. If water breaks are not provided often enough; athletes will not have the opportunity to adequately maintain hydration during activity. Unless ample stations for rehydration are provided, issues may arise with large numbers of players retrieving fluids at the same time. Obstacles towards obtaining fluids were indicated in 23% of participants surveyed in Yeargin et al. study.[26] The personal choice of participants and the circumstance of their exercising environment both functioned to alter the volume of fluid consumed.

Ad Libitum fluid availability indicates individuals are able to access and consume fluids at will, whereas restricted or metered fluid availability only allows fluid consumption during designated time-periods.[16,17]

There has been much debate over the years in regards to which availability is optimal for rehydrating athletes during activity.[16,17,25] Both are plagued with drawbacks, resulting as to why there has been such debate. Ad libitum fluid consumption is highly influenced by thirst mechanisms.[4,16,18] Perceptual feelings of thirst, generally speaking, do not become active until an individual is hypohydrated by two percent body weight.[18] With the known performance detriments and potential EHI concerns, to an extent, ad libitum availability may not be the best atmosphere for prompting adequate rehydration. On the other end of the argument, metered fluid availability possess two issues. However, metered breaks are not often enough and/or long enough, adequate hydration will not be obtained. If breaks are too often and athletes are highly influenced to drink, hypoatremia may be of concern.

In a study conducted by Godek et al,[25] fluid availability was evaluated to determine the effect availability had on fluid intake. A professional football (n=8 players) and Division II collegiate football team (n=8 players) partook in this study. The professional football players were allowed to consume fluids ad libitum during their practices and were afforded ample accessibility to such fluids. The Division II players were restricted to metered water breaks and required to walk a small distance to get to their water. Results from this study identified equal amounts of fluid was consumed. It is important to note, the metered breaks for the Division II players were every 10-15 minutes. This timeline mirrors the suggestions outlined in fluid replacement position stands,[16,17] indicating that for this study, metered breaks were often enough, allowing ample opportunities to hydrate during activity.

Within both the NATA[16] and the ACSM[17] position stands, recommendations have been provided on the frequency of water breaks to promote adequate hydration (roughly 15min intervals). Although thirst perception is a vital mechanism for maintaining fluid balance, other factors pertinent to football (or sports in general) may detract an individual from cueing into their feelings of thirst, thus negating perceptual draws to consume fluid. It seems that the best scheme would be to blend the two; allow for metered breaks roughly every fifteen minutes, but provide additional encouragement by coaches and athletic trainers to allow athletes to consume fluids when they feel the urge to.

Hydration Behaviors

The hydration practices athletes employ prior, during, and following bouts of exercise is essential for maintenance of health and performance.[3,5,16,17] Unfortunately, investigations into the hydration behaviors of athletes indicate athletes often report to practices and/or competition in a hypohydrated state.[12,13,26,30-33] In a study by Volpe et at.,[30] pre-practice hydration status was assessed in a sampling of Division I collegiate athletes. 138 male and 125 female athletes representing fourteen different sports partook in this study. Of the 263participants, 174 (66%) reported to their respective practices in a hypohydrated state. Thirteen percent of the 174 hypohydrated participants were considered significantly hypohydrated. The results illustrated by Volpe et al. are similar to other investigators evaluating like variables across all levels of competition.[13,26,32,33]

As studies have identified that athletes often report to their respective practices and games hypohydrated, further research into the knowledge and attitudes towards hydration has also been explored.[26,32,71,72] In 2005, Nichols et al.[71] investigated the knowledge, attitudes, and behaviors towards hydration and fluid replacement of collegiate athletes. A survey was distributed to the participating athletes (n=139) during their meetings and/or practices. Results from this study indicated these athletes had general hydration knowledge; however, a majority did not correctly answer questions pertaining to the NATA and the ACSM positions stands.

In another investigation, Yeargin et al.[26] evaluated thermoregulatory responses and hydration practices of high school football players during their initial preseason practices. Results from the hydration habits and knowledge questionnaire administered by the participants indicated ninety-two percent reported they understood the importance of drinking before, during, and after exercise, however the average urine osmolality measure indicated these athletes generally experienced minimal to moderate states of hypohydration before (881 ± 285 mOsmol/kg) and after (856 ± 259 mOsmol/kg) each practice evaluated.

Hydration measures and fluid intake observations conducted in this study indicated these athletes hydrated appropriately during their training sessions, however failed to adequately rehydrate prior to the subsequent training session.[26] This was identified by hydration measures of the participants comparing each pre to post exercise bout and between days. Although these athletes experienced hypohydration to a degree throughout the duration of the study, the severity of hypohydration did not progressively deteriorate. These findings are in accordance with other published research.[12,32,72]

Further education on hydration practices would be beneficial to athletes; however, research has indicated even athletes who feel they are knowledgeable in hydration practices and health/performance benefits still arrive to competition hypohydrated.[26,72] To address the issue of reporting hypohydrated, tactics should be employed to promote hydration during and especially following training. Rehydrating post exercise will be extremely dependent on the athlete to fulfill. Hydration during training however can be controlled to a degree by the coaching and Athletic Training staff. By providing an environment that promotes athletes to consume fluids, coaches are enabling their players to exercise longer and perform better, and Athletic Trainers are ensuring preventative measures to limit the chances for developing heat and/or hydration issues

CHAPTER 3

METHODS

A randomized cross-over study design will be utilized to determine the effect of fluid administration on various variables pertaining to fluid consumption, hydration status, and perception during a bout of exercise. Fluid administration is the independent variable, including two levels [self-administration (SA) and external fluid administration (EFA)]. Our control group, SA is defined as squirting the water bottle for one's self without placing the water bottle (WB) on their mouth. Our experimental group, EFA, is defined as someone else squirting the WB for each participant. Participants will perform both conditions in random order on different days. Dependent variables for fluid consumption include volume consumed per fluid break (VC/FB), number of squirts per fluid break (#Sq/FB), squirt volume per fluid break (SqV/FB), total number of squirts (TSq), total volume consumed (TVC) and average volume per squirt (AV/Sq). Hydration variables that will be assessed include urine specific gravity (USG), body mass loss (BML), sweat loss (SwL) and sweat rate (SwRt). Thirst (Th) and fullness (F) will be the perceptual variables evaluated.

Participants

Recreationally active individuals from the local university and running club will be recruited to participate in this study. As inclusion criteria, participants will be between the ages of 18-50 and exercise regularly (≥4 hours a week) for at least six months prior to testing. Individuals meeting these criteria will receive an explanation of all procedures and risk. They will fill out a self-administered health history questionnaire (HHQ), and once comfortable with the details of the study, will sign an informed consent form approved by the university's institutional review board. In review of the HHQ, any individual identifying a prior history of a heat illness within the last 12 months or currently dealing with an injury will be excluded from this study.

Measurements and Instrumentation

Fluid Consumption Variables

To monitor fluid consumed (FC) by participants, individual 1L WB (Gatorade & Co., Chicago, IL) will be assigned to each participant. Each WB will be labeled with a number previously assigned to participants during the familiarization meeting. Prior to fluid breaks (FB), each WB will be filled to the 1L mark. At the completion of FB we will retrieved WB for measuring. A 1000 mL measuring cup will be used to record the remaining fluid in each WB. FC will be calculated by the difference of 1000 mL to fluid remaining in the WB. During each FB we will record the number of squirts each individual takes (SA) or receives (EFA).

Applying FC and #Sq, we will calculate the following variables: (1) SqV/FB-average volume of squirt per condition by FB. (2) TSq-total number of squirts by condition. (3) TVC-volume consumed during all FB by condition. (4) AV/Sq-average volume of squirts by condition over all FB.

Hydration Variables

To measure USG, a clinical refractometer (A300CL; ATAGO Inc., Bellevue, WA) will be used to analyze urine samples collected from each participant prior to and following the exercise protocol (EP).[48] A scale (BWB-800; Tanita, Arlington Heights, IL) will be used to measure participants' mass (semi-nude) pre and post EP.[48,49] Semi-nude will be defined as wearing athletic shorts (and sports bras for females) only. Participants' pre and post EP mass will be used to calculate BML by the difference of pre-EP mass to post-EP mass.[16] Variables also calculated using BML will include SwL (BML + FC – urine output) and SwRt [(BML + FC – urine output)/hours exercised].[16] To negate the need of measuring urine output, participants' pre EP urine sample will be collected before their mass measurement, and during post EP measurements, mass will be recorded prior to obtaining a urine sample.

Perceptual Variables

To assess perceived Th, we will use a 9-point visual scale with verbal anchors ranging from 1 (not thirsty) to 9 (very, very thirsty).[66,73] We will also use a 5-point visual scale with verbal anchors from 1 (not full at all) to 5 (extremely full) to assess perceived sensation of F.[74] Scale administration will occur immediately following the dynamic warm-up and after each exercise station within the EP.

Facilities

A local park will be utilized for data collection. Analysis of data collected will be performed within the supporting department's research laboratory.

Procedures

Prior to the start of testing, each participant will meet with investigators to become familiar with the procedures and review the potential risks. During this meeting, we will provide a detailed explanation of each exercise as well as each fluid administration method. We will provide pictures and written descriptions, as well as demonstrations performed by one of the investigators. We will encourage participants to practice unfamiliar exercises and particularly squirting (SA) and receiving a squirt (EFA) from a WB to establish comfort and ease prior to testing. Participants will also fill out a health history questionnaire (HHQ). The HHQ will serve to provide inclusionary or exclusionary information on each participant.

Upon arrival for testing, participants will randomly selected the order of condition (SA vs. EFA) and their starting exercise station. Once condition and exercise station is assigned, each participant will utilize the local restroom to provide a pre-EP urine sample. Following collection of urine samples, we will record each participant's mass (semi-nude) and provided a daily health questionnaire (DHQ). Before the start of the EP, the DHQ of each participant will be reviewed to identify any potential illnesses or issues that may delay their participation.

Participants will began the EP with a ten-minute dynamic warm-up. Each participant will perform the warm-up at the same time with instruction and demonstration provided by one of the investigators. Immediately following the completion of the warm-up, we will administer the perceptual scales for Th and F. Once all participants provided responses to both scales, we will provide a three-minute fluid break (FB). During each FB, we will record FC and #Sq. Following the first FB (FB1), participants will report to their randomly assigned starting exercise station. The stations are divided into 5 fifteen-minute blocks of exercise with varying tasks and intermittent rest. Rest within these exercise stations will not provide participants the opportunity to consume fluids. With completion of each exercise station, we will ask participants their perceptual values for Th and F. Once Th and F is recorded, five-minute FBs (FB2-FB6) will be provided. After each FB, participants will rotate in a clockwise direction towards the next exercise station. Each cycle of 15-minutes of exercise followed by a 5-minute FB will be repeated until participants complete all five stations (Figure 1). At the completion of FB6, participants will walk back towards the public restrooms for a post-EP weigh-in and urine sample.

Exercise Protocol

All exercises within each station will be repeated until 15 minutes has lapsed. Station 1 (S1) instructs participants to jog up and down a hill for 2 minutes with a 1 minute rest that follows. During station 2 (S2), participants will perform jumping jacks for 2 minutes, 1 minute of up/downs, 1 minute of crunches, followed by 1 minute of rest. Station 3 (S3) consists of ladder drills for 2 minutes, 1 minute of lunges, 1 minute of push-ups, and 1 minute of rest. During Station 4 (S4) participants will jog back and forth between cones for 4 minutes. The arrangement of cones will represent the points to a star, with a cone also positioned in the center between all five cones. We will instruct participants to jog towards the center cone, back pedal back towards the starting cone, and then jog clockwise to the next outside cone to repeat the jogging pattern. After the 4 minutes there will be 1 minute of rest. The last station, Station 5 (S5), entails 1 minute of mountain climbers, 1 minute of bear crawls, 2 minutes of jumping rope, and 1 minute of rest.

Data Analysis

Descriptive statistics will be calculated for each variable. A repeated measures one-way analysis of variance (RM-ANOVA) will analyze condition (SA vs. EFA) by time (FB1- FB6) for VC/FB, #Sq/FB, SqV/FB, Th and F. A RM-ANOVA will be used to analyze condition (SA vs. EFA) by time (Pre vs. Post) for USG. When sphericity is not assumed, a Greenhouse-Geisser adjustment will be used. If interactions are deemed significant by the ANOVA, a paired t-test will be used for post-hoc analysis. Independent samples t-tests will be used to analyze TSq, TVC, AV/Sq, BML, SwL and SwRt by condition (SA vs. EFA). Significance is set a *priori* at $p<0.05$.

CHAPTER 4

MANUSCRIPT

Effect of Fluid Administration on Fluid Consumption and Hydration Status

Introduction

Recent publicity over exertional heat stroke (EHS) fatalities in sports has fostered community and scientific engagement. Over the past fifty years, nearly 100 high school and collegiate athlete deaths have been attributed to complications from an EHS.[1] Awareness has helped support organizations focused on the education and prevention of EHS, as well as prompting further research investigations.

EHS develops when the body is unable to dissipate mounting thermal strain.[2-7] Previous studies have identified numerous factors that may attribute to the development of EHS, including exercising while in a hypohydrated state, cardiovascular fitness, degree of acclimatization, somatotype, sweat rate, sweat profile, equipment requirements, as well as duration and intensity of play.[3-5,7-15] Although there are many factors that may predispose an individual to develop an EHS, exercising in a hypohydrated state hinders the thermoregulatory system and results in heat accumulation. Adequate hydration is vital, as it allows for optimal heat exchange, thus slowing the rate of accumulation. [16,17] Studies in the past have evaluated the influence of fluid characteristics,[16-24] accessibility,[16,17,25-29] and hydration behaviors[3,5,12,13,16,17,26,30-33] in hopes of identifying the optimal environment to promote adequate fluid consumption.

Although any individual may develop EHS, the prevalence of hypohydration among football players is high.[1,9,11-13,34-37] During observation of sidelines during football practices and games, one may observe individuals squirting water into athletes mouths, instead of handing the athlete the water bottle (WB). This method of fluid administration is commonly utilized during football activity, yet the adequacy of this fluid delivery method is unknown. The purpose of our study was to investigate the effect fluid administration has on fluid consumption, hydration status, and perceptual feelings of thirst and fullness. We hypothesized that (1) self-administration (SA) would encourage more fluids than external fluid administration (EFA), (2) EFA would become increasingly hypohydrated, and (3) EFA would feel thirstier and less full compared with SA.

Methods

A randomized cross-over study design was utilized to determine the effect of fluid administration on myriad variables pertaining to fluid consumption, hydration status, and perception during a bout of exercise. Fluid administration was the independent variable, including two levels (SA and EFA). Our SA control group was defined as squirting the WB for one's self without placing the WB on their mouth. Our experimental group, EFA, was defined as someone else squirting the WB for each participant (Figure 1). Efforts were made to assure adequate comparison among SA and EFA without bias. EFA was controlled by administrators who were unaware of the hypotheses of the study. Participants were instructed to consume as little or as much fluid as they wanted during breaks. Breaks were audibly labeled "fluid breaks." Participants were neither encouraged nor discouraged to consume fluids at any point during the study. Participants performed both conditions in random order on different days ($\leq$ 4days between conditions). Dependent variables for fluid consumption included volume consumed per fluid break (VC/FB), number of squirts per fluid break (#Sq/FB), squirt volume per fluid break (SqV/FB), total number of squirts (TSq), total volume consumed (TVC) and average volume per squirt (AV/Sq). Hydration variables assessed include urine specific gravity (USG), body mass loss (BML), sweat loss (SwL) and sweat rate (SwRt). Thirst and fullness were the perceptual variables evaluated.

Participants

Twenty two recreationally active individuals from the local university and running club volunteered to participate in this study. During the course of data collection, three participants dropped out of the study due to time constraints. The data collected on these participants were not included in data analysis. Nineteen participants [14 Males, 5 Females (age = 30±10y, height = 176±8cm, mass =72.5Kg)] completed all conditions and were included into data analysis. Participants were required to be between the ages of 18-50y and exercise regularly (≥4 hours per week) for at least six months prior to testing. Individuals meeting these criteria received an explanation of all procedures and risk. They completed a self-administered health history questionnaire (HHQ), and once comfortable with the details of the study, signed an informed consent form approved by the university's Institutional Review Board. In review of the HHQ, any individual identifying a prior history of a heat illness within the last 12 months or currently dealing with an injury was excluded from participation.

Instrumentation and Measurements

Environmental Condition

A heat stress WBGT thermometer (Metrosonics HS-32 area heat stress monitor; Quest Technologies, Oconomowoc, WI) was used to monitor environmental conditions between testing days.

Fluid Consumption

To monitor fluid consumed (FC) by participants, individual 1L WB were assigned to each participant. Each WB was labeled with a number previously given to the participant during a familiarization meeting. Prior to fluid breaks, each WB was filled to the 1L mark. At the completion of fluid breaks we retrieved WB for measuring. A 1000 mL measuring cup (±25mL) was used to record the remaining fluid in each WB. FC was calculated by the difference of 1000 mL to fluid remaining in the WB. During each FB we recorded the number of squirts each individual took (SA) or received (EFA). Using a thermometer (4600; YSI, Yellow Springs, OH), temperature of water (3±1°C) within the dispensing cooler was monitored to ensure consistent fluid temperature across testing days.

Applying FC and #Sq, we calculated the following variables: (1) SqV/FB-average volume of squirt per condition by FB. (2) TSq-total number of squirts by condition. (3) TVC-volume consumed during all FB by condition. (4) AV/Sq-average volume of squirts by condition over all FB.

Hydration Measures

To measure USG, a clinical refractometer (A300CL; ATAGO Inc., Bellevue, WA) was used to analyze urine samples collected from each participant prior to and following the exercise protocol (EP).[38] A scale (BWB-800; Tanita, Arlington Heights, IL) was used to measure participants' mass (semi-nude) pre and post EP.[38,39] Semi-nude was defined as wearing athletic shorts (and sports bras for females) only. Participants' pre and post EP mass was used to calculate BML by the difference of pre-EP mass to post-EP mass.[16] Variables also calculated using BML include SwL (BML + FC – urine output) and SwRt [(BML + FC – urine output)/hours exercised].[16] To negate the need of measuring urine output, participants' pre EP urine sample was collected before their mass measurement, and during post EP measurements, mass was recorded prior to obtaining a urine sample.

Perceptual Variables

To assess perceived Th, we used a 9-point visual scale with verbal anchors ranging from 1 (not thirsty) to 9 (very, very thirsty).[40,41] We used a 5-point visual scale with verbal anchors from 1 (not full at all) to 5 (extremely full) to assess perceived sensation of F.[42] Scale administration occurred immediately following the dynamic warm-up and each exercise station within the EP.

Facilities

A local park was utilized for data collection. Analysis of data collected was performed within the supporting department's research laboratory.

Procedure

Prior to the start of testing, each participant met with investigators to become familiar with the procedures and review the potential risks. During this meeting, participants received a detailed explanation of both fluid administration methods, as well as each exercise within the EP. Pictures and written descriptions were provided, as well as demonstrations performed by one of the investigators. We encouraged participants to practice unfamiliar exercises and particularly squirting (SA) and receiving a squirt (EFA) from a WB to establish comfort and ease prior to testing. Participants also completed health history questionnaire (HHQ). The HHQ served to provide inclusionary or exclusionary information for each participant. During this meeting we also verbally asked participants to avoid salty foods and alcoholic beverages 24 hours prior to testing.

Upon arrival for testing, participants randomly selected the order of condition (SA vs. EFA) and the starting exercise station. Once condition and exercise station was assigned, each participant utilized the local restroom to provide a pre-EP urine sample. Following collection of urine samples, we recorded each participant's mass (semi-nude) and provided a daily health questionnaire (DHQ). Before the start of the EP, the DHQ of each participant was reviewed to identify any potential illnesses or issues that may delay their participation.

Participants began the EP with a ten-minute dynamic warm-up. Each participant performed the warm-up at the same time with instruction and demonstration provided by one of the investigators. Immediately following the completion of the warm-up, we administered perceptual scales for thirst and fullness. Once all participants provided responses to both scales, a three-minute fluid break (FB1) was provided. During each fluid break, we recorded FC and #Sq. Following the FB1, participants reported to their randomly assigned starting exercise station. The stations were divided into 5 fifteen-minute blocks of exercise with varying tasks and intermittent rest. Rest within these exercise stations did not provide participants the opportunity to consume fluids. With completion of each exercise station, we asked participants their perceptual values for thirst and fullness. Once thirst and fullness were recorded, five-minute fluid breaks (FB2-FB6) were provided. After each fluid break, participants rotated in a clockwise direction towards the next exercise station. Each cycle of 15-minutes of exercise followed by a 5-minute fluid break was repeated until participants completed all five stations (Figure 2). Over the duration of the EP, participants exercised for 75 minutes and rested for 25 minutes. At the completion of FB6, participants walked back towards the public restrooms for a post-EP weigh-in and urine sample.

Exercise Protocol

Exercises at each station were repeated until 15 minutes had lapsed. At station 1 participants jogged up and down a hill for 2 minutes with a 1 minute rest. During station 2, participants performed jumping jacks for 2 minutes, 1 minute of up/downs, 1 minute of crunches, followed by 1 minute of rest. Station 3 consisted of ladder drills for 2 minutes, 1 minute of lunges, 1 minute of push-ups, and 1 minute of rest. During Station 4 participants jogged back-and-forth between cones for 4 minutes. The arrangement of cones represented the points of a star, with a cone also positioned in the center between all five cones. We instructed participants to jog towards the center cone, back pedal back towards the starting cone, and then jog clockwise to the next outside cone to repeat the jogging pattern. After 4 minutes of exercise, participants rested for 1 minute of rest. The last station, Station 5, entailed 1 minute of mountain climbers, 1 minute of bear crawls, 2 minutes of jumping rope, and 1 minute of rest.

Data Analysis

Descriptive statistics were calculated for each variable. A repeated measures one-way analysis of variance (RM-ANOVA) was used to assess condition (SA vs. EFA) by time (FB1-FB6) for dependent measures (VC/FB, #Sq/FB, SqV/FB, thirst and Fullness). A RM-ANOVA was used to analyze condition (SA vs. EFA) by time (Pre vs. Post) for USG. When sphericity was not assumed, a Greenhouse-Geisser adjustment was used. If interactions were deemed significant by the ANOVA, a paired t-test was used for post-hoc analysis. Independent samples t-tests were also used to analyze TSq, TVC, AV/Sq, BML, SwL and SwRt by condition (SA vs. EFA). Significance was set a *priori* at $p<0.05$. SPSS (version 18; SPSS Inc., Chicago, IL) was used to analyze the data.

Results

Environmental Condition

Environmental measures are expressed as means with standard deviations for dry bulb (26.1±4.4), wet bulb (19.4±2.9), black globe (30.0±7.0), relative humidity (45.8±12.7), and wet bulb globe temperature (22.1±3.6).

Fluid Consumption

There was no significant interaction ($F_{1,5}$=1.218, p>0.05, 1-β=.354) between condition and time for the amount of FC by participants during fluid breaks. There was however a main effect for condition ($F_{1,5}$=9.025, p<0.05, ES=.200) and time ($F_{1,5}$=15.864, p<0.05, ES=.306). Method of SA promoted the greatest amount of FC by participants during all fluid breaks (Figure 3).

Number of squirts per fluid break indicated a significant interaction ($F_{1,5}$=2.918, p.05, ES=.075) between condition and time. There was no main effect for condition ($F_{1,5}$=0.118, p>0.05, 1-β=.063), however there was a main effect of time ($F_{1,5}$=21.74, p<0.05, ES=.377), indicating FB1 was significantly less than all other fluid breaks (Table 1).

Average volume of squirt by condition for each fluid break indicated no significant interaction ($F_{1,5}$=0.871, p>0.05, 1-β=.124), however there was a main effect for condition ($F_{1,5}$=6.087, p<0.05, ES=0.145) and of time ($F_{1,5}$=5.116, p<0.05, ES=.124). There was a significant difference between conditions during FB2, FB5, and FB6, indicating SA prompted more volume per squirt (Figure 3). FB1 (17±15mL) and FB2 (20±12mL) was significantly less compared with FB3-FB5 (26±17mL; 26±14mL; 26±11mL, respectively). FB1 was also significantly less than FB6 (22±11mL), and FB5 was significantly more volume per squirt than during FB6 (Figure 4).

In regards to TSq, SA took more squirts (35±15) then EFA received (33±12), however no significant differences (t_{18}=0.565, p>0.05) were indicated. There was a significant difference in TVC (t_{18}=3.932, p<0.05) between SA (867±312 mL) and EFA (604±220 mL). The average volume of squirts by condition, over the entire EP was significantly different (t_{18}=2.930, p<0.05) between SA (27±10 mL) and EFA (19±9 mL).

Hydration Measures

With no significant interaction between condition and time for USG ($F_{1,1}$=.015, p>0.05, 1-β=.052), participants arrived hydrated (USG: SA=1.016±.009; EFA=1.019±.008) and remained hydrated (USG: SA=1.019±.008; EFA=1.020±.007) throughout the EP. There was no main effect for condition ($F_{1,1}$=.544, p>0.05, 1-β=.111). There was a main effect of time ($F_{1,1}$=4.863, p<0.05, ES=.119), indicating pre USG (1.017±.009) was significantly lower than post USG (1.021±.007). There was no statistically significant difference in BML (t_{18}=-1.468, p>0.05) between SA (0.99±.45Kg) and EFA (1.17±.43 Kg), nor was there a significant difference in SwL (t_{18}=0.779, p>0.05) or SwRt (t_{18}=0.779, p>0.05) between SA (1.86 ±.48L; 1.24±.32L) and EFA (1.78±.39 L; 1.19±.26), respectively.

Perceptual Variables

There was no significant interaction ($F_{1,5}$=1.920,p>0.05,1-β=.523) between condition and time for thirst. There was no main effect for condition ($F_{1,5}$=2.142, p>0.05, 1-β=.297) however, there was a main effect of time($F_{1,5}$=15.266,p<0.05,ES=.298). Participants' perception of thirst during FB1 was significantly less compared with all other fluid breaks (p<0.05) and FB4 indicated less perception of thirst compared with FB3-FB6 (Figure 5).

Statistical significance was indicated with the interaction of condition and time for fullness ($F_{1,5}$=3.146,p<0.05,ES=.08). There was no main effect for condition ($F_{1,5}$=.786, p>0.05, 1-β=.139) nor of time ($F_{1,5}$=.844, p>0.05, 1-β=.241). Regardless of conditions, average value reported was 2±1 (Table 2).

Discussion

We evaluated the effect of SA and EFA on participant fluid consumption, hydration status, and perception of thirst and fullness during exercise. Our results indicated participants consumed more fluids during SA compared with the EFA method. Hydration status and reported perceptual values did not significantly differ between conditions. Currently a vast body of research is available investigating hydration variables and their influence on fluid consumption and hydration status. Fluid palatability has been extensively researched[7,16-19,23,43-46] and two factors in particular have been indicated as highly influencing fluid intake; temperature and flavor. In regards to fluid temperature, Boulze et al[23] study indicated participants consumed the greatest amount of fluid when the temperature was 15°C. These results mirror similar research investigations, as well as the current recommendations set forth by the Nation Athletic Trainers Association[16] and American College of Sports Medicine[17] regarding fluid replacement for athletes. A study evaluating fluid temperature and flavor by Szlyk et al,[19] identified reluctant drinkers (>2% BML) consume more warm fluids when flavor is added. Temperature and flavor are two fluid variables well researched and often utilized to promote fluid intake. Although in our study we selected to use water instead of a flavored beverage, we did monitor the temperature of fluids consumed during each training session throughout the entire duration of data collection. This was to ensure consistency and limit the effect of fluid temperature on volume of FC. The average temperature of water in our study was 3±1°C, measured from within the dispensing cooler. We assume the actual temperature of water consumed by participants was slightly warmer than 3°C because during the exercise stations the WB sat in the sun; however the WB were replenished after each fluid break.

Another area well researched to enhance fluid consumption, involves fluid availability. A study conducted by Kaushik et al[47], evaluated FC by children at school with different means of fluid availability. Three groups (restricted access, limited access, free access) were examined and the results indicated the group with free access consumed more fluids compared with the limited and restricted groups. In contrast to this study, our groups received the same opportunity to consume fluids, thus FC by participants was not affected by availability of fluids. However, the availability of fluids provided to our participants may in part explain why during both conditions participants remained euhydrated.

In another study evaluating fluid availability, Godek et al[25] assessed NFL and collegiate football players with varying accessibility to fluids. Results from this study indicated no matter immediate access, or a short distance away, rate of FC was not affected. It is important to note, the group that had a short distance to obtain fluids were allotted fluid breaks every 10-15 minutes. The frequency of fluid breaks within this group mirror the current suggestions outlined within fluid replacement position stands.[16,17] Our study was designed to follow the current recommendation, allowing for fluid breaks every 15 minutes throughout the duration of the EP. The hydration status observed in our participants may in part be attributed to the frequency and duration of fluid breaks provided.

As the body of research continues to grow, new variables are in need of investigation, such as fluid administration. A study similar to ours, with respect to evaluating fluid delivery, is that by Bowman et al[48]. This study evaluated the efficiency of drinking fluids by varying means (WB-mouth on, WB-mouth off, paper cup, and water fountain). Results from this investigation indicated drinking from a cup was most efficient and drinking from a water fountain was the least efficient. Although we did not evaluate efficiency, there may be a difference between SA and EFA, which may have played a role in the amount of fluids consumed. In Bowman et al study[48], fluid consumption from a WB was evaluated and indicated 88.6% and 84.6% efficiency for WB-mouth on and WB-mouth off, respectively. Our SA condition is comparable to Bowman's WB-mouth off condition. Although not investigated, we speculate EFA would be less efficient than SA. We attribute the efficiency discrepancy to self-control versus external control over the WB. By allowing one's self to squirt the WB, sensory feedback is incorporated and may contribute to the accuracy of the squirt to reach one's mouth, thus influencing the efficiency of the fluid administration method.[49] Efficiency of fluid administration becomes important when time for fluid consumption is limited, as may be the case with athletes during competitive play.

While numerous studies have evaluated factors influencing quantity of fluids consumed during exercise; self verse external administration to our knowledge has not been investigated prior to this study. The primary results for our study indicate SA promotes consumption of more fluids, both per-squirt and cumulatively over the duration of exercise as compared to EFA. Participants' hydration (USG, BML, SwL, SwRt) and perceptual measures (thirst and fullness) were not affected by method of fluid administration, likely due to the numerous fluid breaks provided, exercise demands of the EP, and the availability of participants to self-pace. Hydration status and perceptual measures may have reported differently in a more practical setting. As highlighted within the NATA[16] position statement, accessibility, personal choice, circumstance of competition and/or personnel, or any combination of these factors, have been attributed to why athletes generally do not rehydrate adequately during activity. Participants in our study reported and remained euhydrated throughout the EP, and across testing days. Factors identified within the NATA position statement may not have played an influencing role in our study due to the design of the EP and the demographic of our participants. However within a competitive setting, athletes may be less apt to rest as often and have as much availability and focus on consuming fluids during fluid breaks.

Fluid Consumption

During all fluid breaks, participants consumed more fluids via SA compared with EFA. Differences in fluid consumed between conditions may be attributed to the comfort level of receiving fluid via the differing methods. We believe the sensory feedback involved with SA influenced the more fluid consumed compared with EFA. By allowing individuals to hold their own WB, the somatosensory input system provided a connection between self want and the WB. Tactile, conscious proprioceptive, and temperature senses are inputs utilized during SA, which are not used during EFA.[49] When an individual holds the WB for themselves, tactile receptors send signals to the brain to interpreted and appreciate the feeling of holding the WB, its weight, and the pressure and duration required for a squirt. Conscious proprioceptive senses including kinesthesia, joint position sense, and sense of resistance also factor into the connection between self want and the WB.[49] SA promoted the use of these proprioceptive senses to appreciate the location of the arm in space, and the WB as an extension of the arm. In turn, feed-forward control allows for squirting to become more familiar, thus increasing the chance for more accurate or efficient squirts.[49]

Thermoreceptors within the hand may have also influenced the difference in volume consumed between conditions. Past research[16,18,19,23] has evaluated the influence of temperature on volume consumed, and has indicated fluids are consumed in greatest amount around 15°C. A study conducted by Boulze et al[23] evaluated the effect of fluid temperature on fluid consumption and reported alliesthesia. Results indicated 15°C promoted the greatest volume of fluid consumed, and when participants were able to mix the water to their preferred temperature, they choose 14.9°C. Results from the alliesthesia scale indicated increased pleasure with progressively cooler fluids. To our knowledge, the temperature of the container or WB housing the fluid has not yet been evaluated for its influence on fluid consumption; however, we speculate the appreciation of the WB temperature during the SA condition contributed to the greater TVC observed compared with EFA.

Identifying factors that influence consumption of more fluids is ideal, as past investigations have indicated athletes tend to not rehydrate adequately during activity.[16] Numerous studies[14,25,41,42,50,51] have evaluated volume of fluids consumed during varying tasks. In a study by Aragon-Vargas et al,[42] professional soccer players consumed 1948 ± 954 mL of fluid over a three hour span during a competitive soccer match, equating to 649 mL/h. In a similar study evaluating soccer players, Shirreffs et al[50] also reported an average fluid intake of 650 mL/h. Other studies[14,25,41,51] have indicated even greater volume of fluid consumed by participants. In contrast to past studies, both conditions in our study consumed less volume of fluid per hour (SA=578 mL and EFA=403 mL). Consumption of less fluid may be due in part to the type of exercise protocol and participants involved. The majority of these studies measured hydration status during competitive sport play, whereas in our study recreationally active individuals performed individualized, structured exercises. This may have influenced an individual's competitive nature, thus the level of intensity, and in turn, influencing the volume of fluids consumed.

Number of Squirts

To our knowledge, there is no other study reporting number of squirts as a hydration variable. In our study, there was no significant difference in #Sq between conditions, which was surprising because the TVC was significantly different. We thought the awkward nature of asking someone else to squirt the WB would have influenced the number of squirts taken by participants. All fluid breaks had insignificant differences in #Sq aside from FB1. During FB1 participants did not squirt as frequent as all other fluid breaks. This is likely due to the difference in demands; FB1 followed the dynamic warm up, whereas all other fluid breaks were after an exercise station. We suspect these results would be similar to an athletic event where during warm ups, less squirts are taken compared with during competitive play. Our results may also be attributed to comfort level with asking for a squirt from an EFA. This may be similarly the case in athletics where a freshman may be initially timid to request squirts, however after observing other teammates, they feel comfortable enough to ask for squirts.

Average Squirt Fluid Volume

As previously mentioned, Aragon-Vargas et al[42] study evaluated fluid intake of soccer players during competitive play. Within their methods, it was noted that a few players drank from unlabeled WB. In order to account for fluids consumed by those players, number of gulps was counted. Authors of this study attributed one gulp to equal 30mL consumed; however they did not mention how they selected to use 30mL to represent each gulp. Compared with our study, we were able to calculate average volume per squirt, by FC and #Sq (SA=27±10 mL and EFA=19±9 mL).

Although our results indicated no difference in #Sq, AV/Sq was significantly different between conditions. Our results on AV/Sq may be attributed to personal choice, the circumstance of activity and/or personnel, which are factors identified within the NATA[16] position statement as influencing adequate hydration during activity. During EFA fluid breaks, each investigator was assigned to as many as five participants at a time to provide squirts. Participants may have been vying for squirts at the same time, which may have influenced duration of each squirt by research aides. Practically, this may be similar to practices and games where the ratio of athletes to fluid providers is much greater than five to one. With a greater number of athletes vying for a squirt, the frequency and duration of squirts are likely to be affected, in turn influencing the volume of fluids consumed. SA however, did not pose a sense of competition because each individual was responsible for their own consumption, rather than depending on someone else. By providing individuals their own WB to drink from, they are able to control the force and duration of each squirt, thus allowing the opportunity for more fluid per squirt, which over the duration of activity will result in greater volume consumed.

Hydration Measures

Participants arrived and remained hydrated throughout the EP. USG indicated significance of time between pre-EP and post-EP. The hydration behaviors of athletes have been extensively evaluated and indicate athletes often report to practices and/or competition in a hypohydrated state.[12,13,26,30-33] In a study by Volpe et al[30], 174 of 263 participants involved reported to their respective practices in a hypohydrated state. Results illustrated by Volpe et al are similar to other investigations evaluating like variables across all levels of competition.[13,26,32,33] Unlike these investigations, our participants reported and remained euhydrated, likely due to differences in the nature of data collection (research vs. normal sport play), exercise demands, frequency of fluid breaks, and the ability of our participants to self-pace.

In another hydration study, Godek et al[13] measured USG to assess hydration status of collegiate football players during consecutive days of two-a-day preseason practices. Results from this investigation identified athletes reported to baseline measurements in a euhydrated state (USG=1.0175±.006), however each training day that followed, athletes reported and remained hypohydrated. Participants in Godek et al study reported similar USG as our study only during their baseline session. As previously indicated, athletes often arrive in a hypohydrated state. In Godek et al study, a hydration protocol was implemented the night prior to baseline measurements; this may be why participants reported euhydrated. In contrast, participants in our study reported and remained hydrated throughout the EP, and did not experience residual hypohydration between testing days. Knowledge of the purpose of the study and the EP may have influenced participants to hydration differently from their normal habits prior to testing days.

Body mass loss was not significantly different between SA and EFA, likely due to the frequency and duration of fluid breaks provided throughout the EP. Unlike fluid breaks during practices and/or games where numerous distractions are present, participants in our study were able to intently focus only on consuming fluids. By allowing ample opportunity for fluid consumption, participants were able to remain hydrated throughout the EP. In an article by Sun et al[44], dehydration rates and rehydration efficacy of varying types of fluids were assessed in flat-water kayakers. Results from this investigation identified BML of 0.46±.27 Kg (Gatorade) and 0.7±.39 Kg (water) in participants. In contrast, our results indicated a greater BML (SA=.99±.45 Kg; EFA=1.17±.43 Kg), even though USG and FC/hr were similar between studies. The difference in BML between Sun et al and ours may be attributed to the training level of participants. Our study utilized recreationally active individuals, whereas Sun et al evaluated well-trained kayakers. Participants in our study may have experienced greater BML, despite similar USG and FC/hr due to insufficient cardiopulmonary and thermoregulatory training. When individuals are well trained, oxygen exchange and circulatory cooling mechanisms are enhanced[5]. This may explain why the kayakers experienced less BML compared with our participants.

Fluid administration had no effect on SwL or SwRt (SA=1.86 ±.48L; 1.24±.32L and EFA=1.78±.39 L; 1.19±.26L, respectively). Both sweat loss and rate observed in our study are similar to other studies assessing sweat variables.[42,50-52] In comparison, a study conducted by Osterberg et al[33] evaluating professional basketball players, identified larger sweat losses (average 2L over 20 minutes of play). The difference in results may be attributed to the intensity and demands required. In contrast to the demands of a basketball game, our EP was designed to allow intermittent breaks within and between each exercise station. The frequency of rest and FB may have contributed to participants experiencing a relatively low thermal strain, as well as maintenance of hydration status.

Perceptual Variables

Fluid administration had no effect on thirst or fullness. Reporting on thirst, FB1 was significantly different compared with all other fluid breaks. This is likely due to the task preceding FB1. All other fluid breaks followed completion of an exercise station, whereas FB1 was assessing fluid intake and perceptual values following the dynamic warm up. A study with similar design by Rivera-Brown et al[45] assessed fluid composition on fluid balance and perception of thirst and fullness during a bout of cycling. Participants cycled for twenty minutes, four times with 25 minutes of rest between each cycling bout. Although the protocol was slightly longer in duration, FC/hr was similar. Reports on thirst and fullness however, were not similar.

The cycling participants reported feeling less thirst and full compared with our study. Differences in results may be due to differences in task, length of rest/breaks, and/or differences in populations (adolescents vs. adults). Stomach fullness is largely dependent on the rate of gastric filling to gastric emptying. If the rate of filling outweighs emptying, fullness increases in direct proportion to the imbalance.[17] Our results indicate participants did not consume enough fluids to challenge reported gastric emptying rates[17], thus preventing reporting dramatic increases in stomach fullness by participants.

Another study assessing the influence of thirst on drinking is that by Maresh et al.[53] Participants in this study performed 4 trials of treadmill walking while varying hydration status and ability to consume fluids. Results from this investigation identified the dehydrated group felt thirstier before the EP and drank more fluids during the EP compared with the euhydrated group. These results indicated dehydration prior to exercise heightens thirst driven drinking. A study by Engell et al[41] reported similar results, indicating fluid intake directly correlated with hypohydration level. Our participants reported and remained euhydrated throughout the EP and indicated only little to moderate feelings of thirst and fullness. With the hydration status of our participants coupled with their perceptual responses, it is likely thirst and fullness did not drive fluid consumption. Rather, the type of fluid administration influenced the amount of fluid consumed.

Conclusion

The type of fluid administration influences the amount of fluid consumed during a bout of exercise. Additionally there was no effect on hydration status (USG, BML, SwL and SwRt) or perceptual measures (thirst and fullness), likely due to the EP chosen. SA promoted more TVC, likely due to greater volume per squirt observed in our study. Euhydration may have been maintained in both conditions due to the frequency of FB. If fluid breaks were less frequent, EFA may result in more BML, leading towards hypohydration. Therefore, Athletic Trainers and healthcare providers should allow athletes to squirt their own bottle during practices and games to promote better hydration behaviors.

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Table 1 Number of Squirts per Fluid Break by Condition (Mean ±SD).

Number of Squirts per Fluid Break		
	SA	**EFA**
FB 1 [a]	4±3	2±2
FB2	7±4	5±3
FB3	6±3	7±3
FB4	6±3	7±3
FB5	6±3	7±2
FB6	6±3	6±3

SA= self-administration

EFA= external fluid administration

a = FB1<FB2-FB6 ($p<0.05$)

Table 2 Reported Values for Sensation of Fullness by Condition per Fluid Break (Mean±SD).

Fullness		
	SA	**EFA**
FB1	2±1	2±1
FB2	2±1	2±1
FB3	2±1	2±1
FB4	2±1	2±1
FB5	2±1	1±1
FB6	2±1	2±1

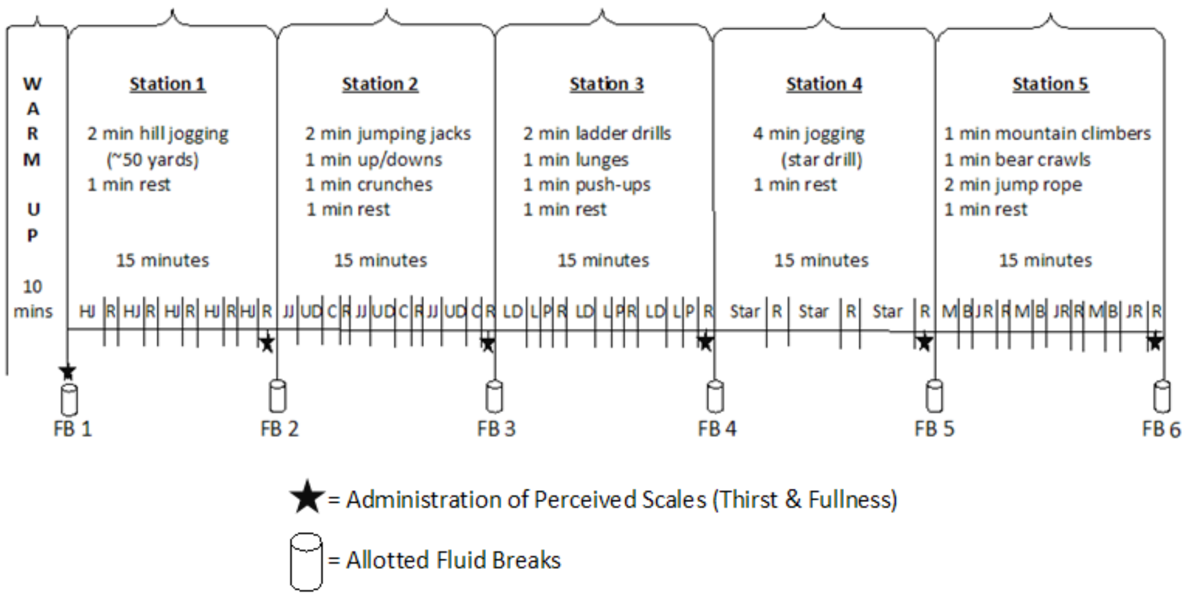
SA= self-administration; EFA= external fluid administration

Figure 1. Fluid Administration Methods.

Self-Administration (SA)

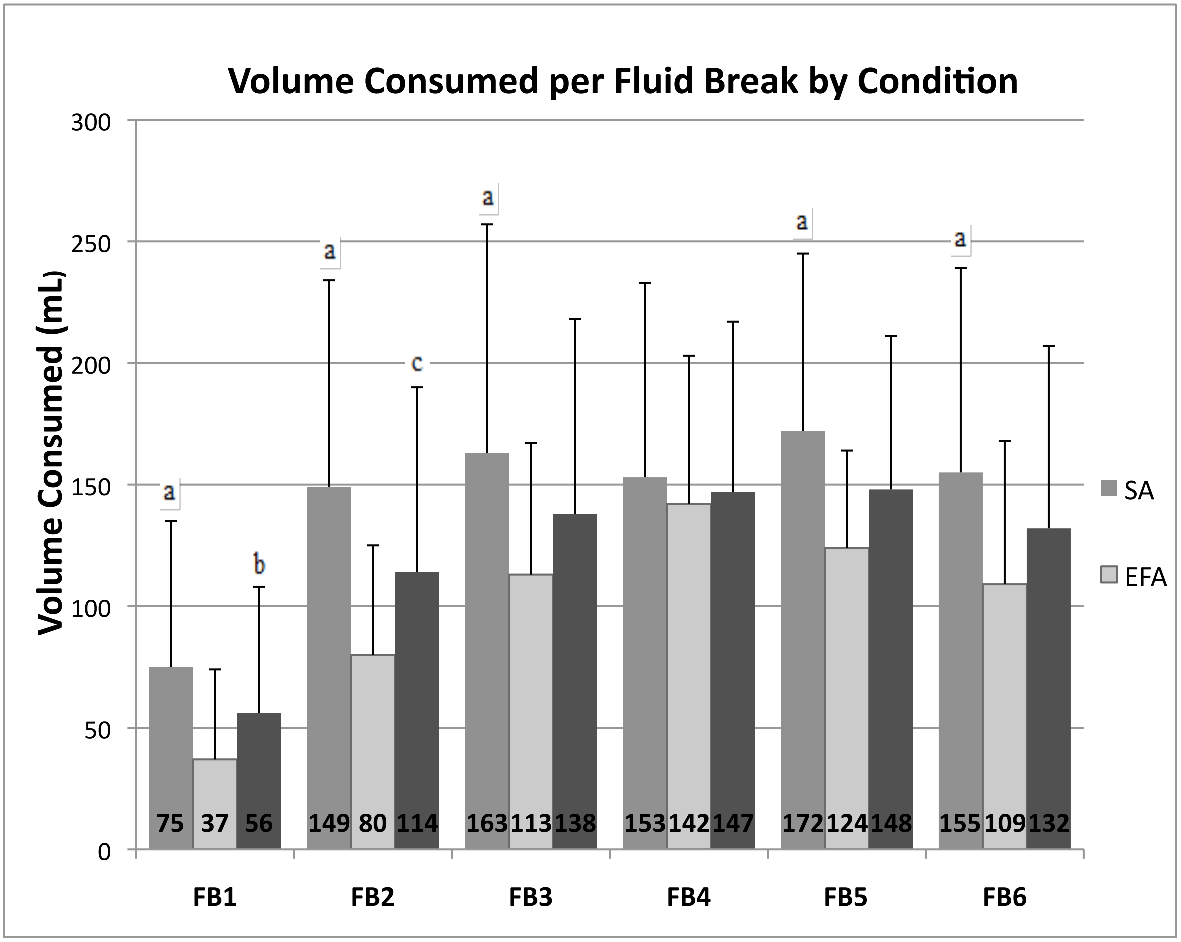
External Fluid Administration (EFA)

Figure 2. Schematic of Exercise Protocol.



FB= fluid breaks

Figure 3. Volume consumed per Fluid Break by Condition (Mean ± SD).



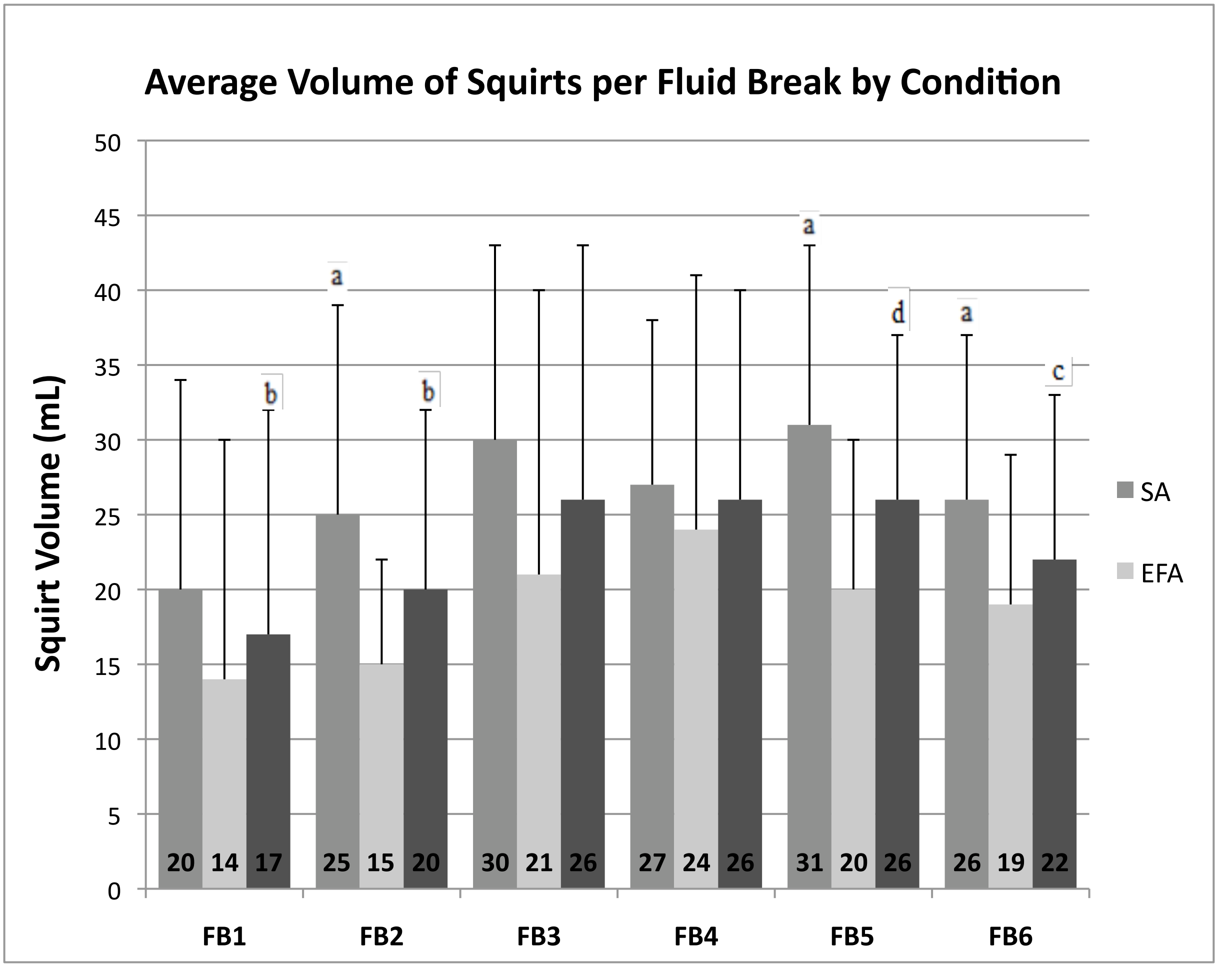
SA= self-administration; EFA= external fluid administration; FB= fluid breaks

a = SA > EFA (p<0.05)

b = FB1<FB-2FB6 (p<0.05)

c = FB2<FB2-FB5 (p<0.05)

Figure 4. Average Volume of Squirts per Fluid Break by Condition (Mean ± SD).



SA= self-administration; EFA= external fluid administration; FB= fluid breaks

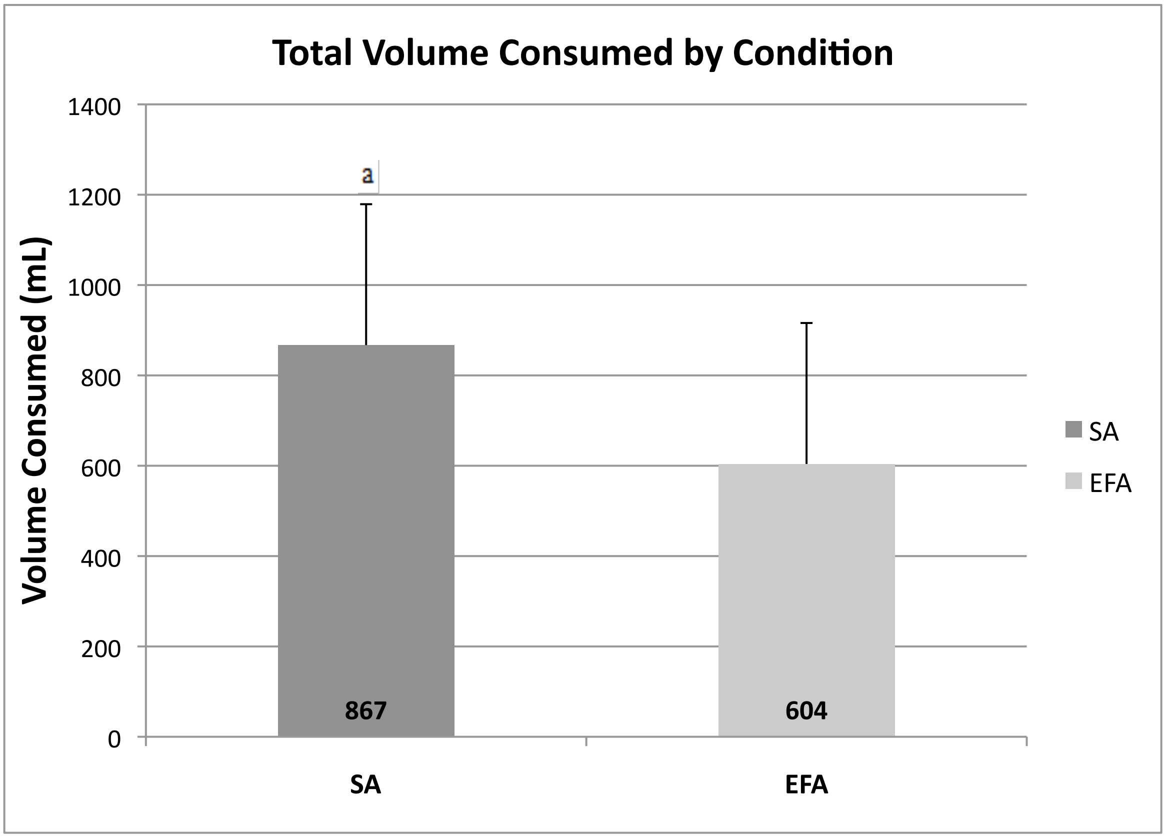
a = SA>EFA ($p<0.05$)

b = FB1 & FB2<FB3-FB5 ($p<0.05$)

c = FB1<FB6 ($p<0.05$)

d = FB5>FB6 ($p<0.05$)

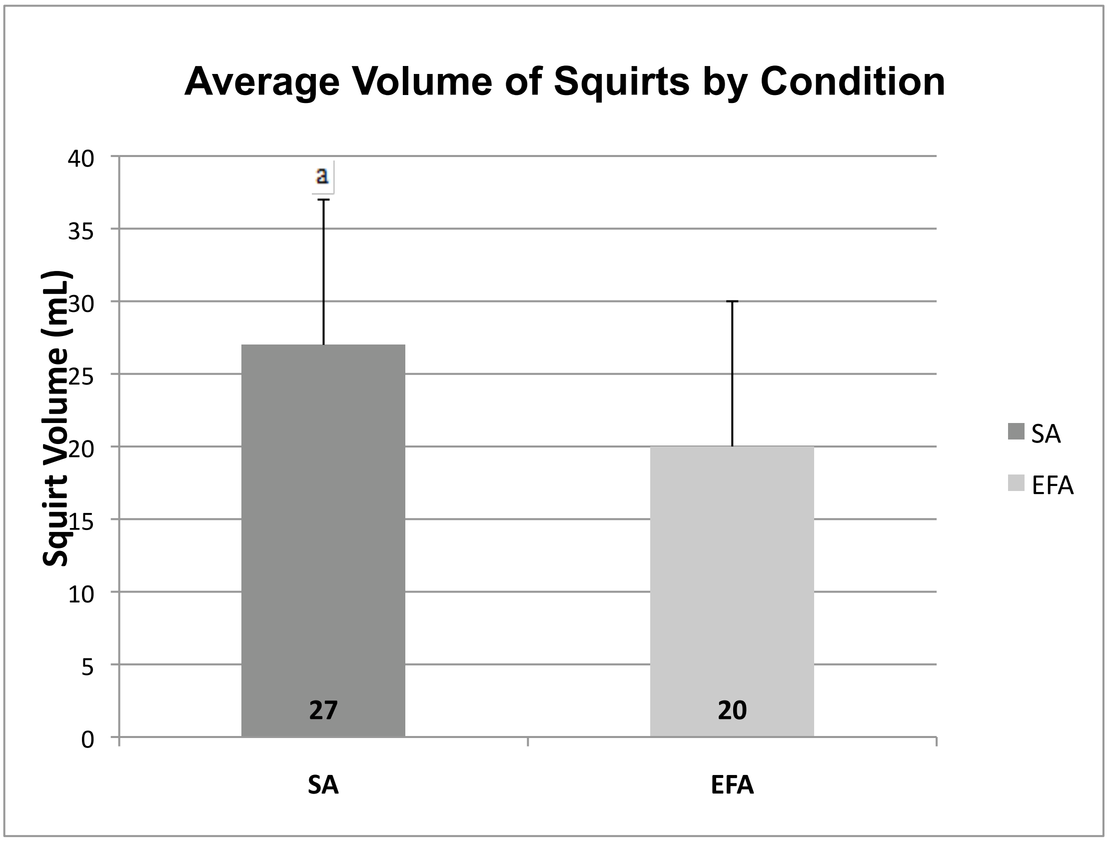
Figure 5. Total Volume of Fluid Consumed by Condition.



SA= self-administration; EFA= external fluid administration

[a] = SA>EFA ($p<0.05$)

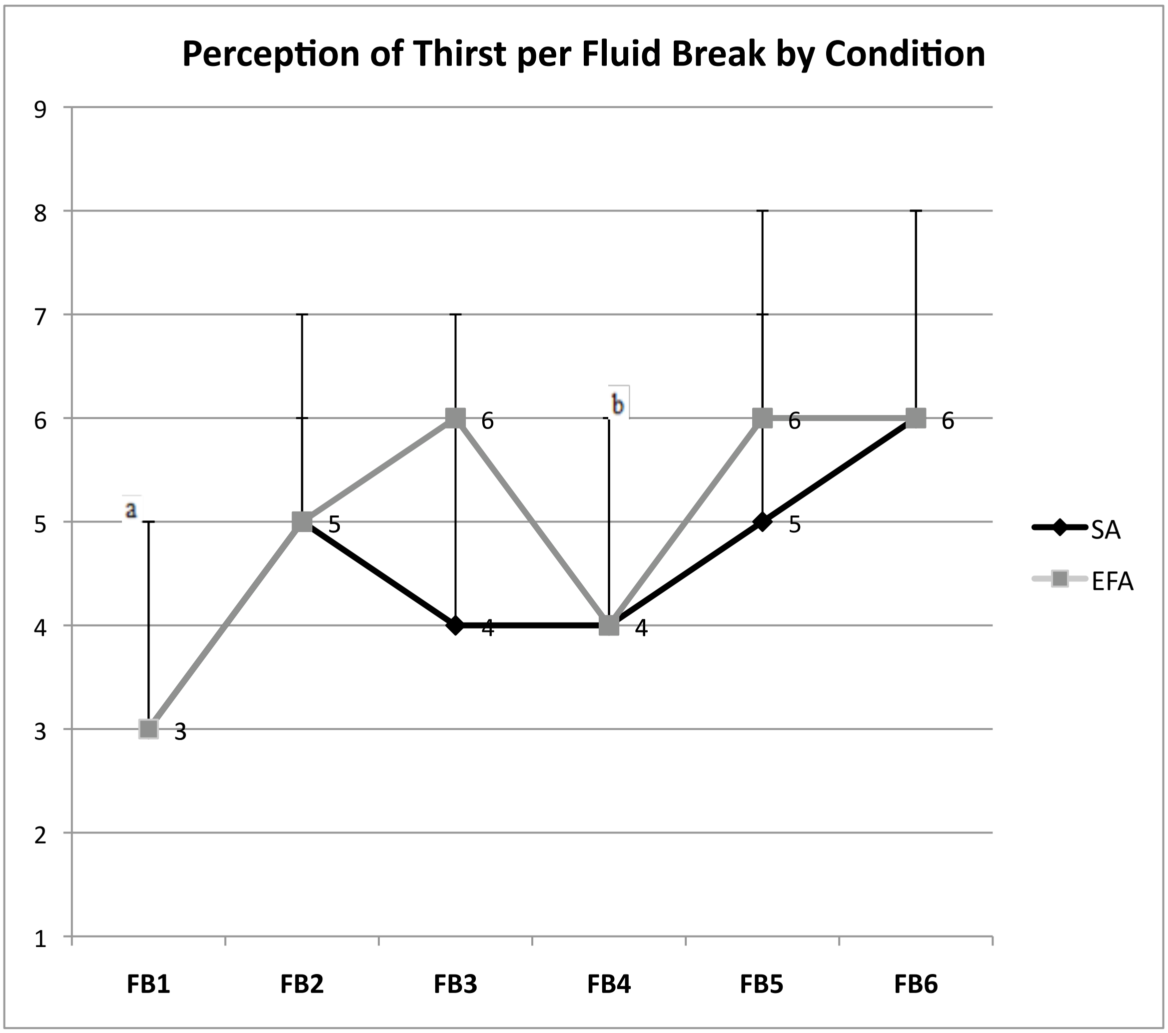
Figure 6. Average Volume of Squirts by Condition.



SA= self-administration; EFA= external fluid administration

a = SA>EFA ($p<0.05$)

Figure 7. Perceived Thirst per Fluid Break by Condition.



SA= self-administration; EFA= external fluid administration; FB= fluid breaks

Thirst scale (1= not thirsty; 9 = very, very thirsty)

a = FB1<FB2-FB6 ($p<0.05$)

b = FB4<FB3, FB5-FB6 ($p<0.05$)

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APPENDIX A: STUDY PARAMETERS

<u>Operational definitions</u>

Fluid Administration: Methods by which fluids are transferred from the water bottle to participants' mouth.

Self-Administration (SA): Method of fluid administration that involved participants squeezing the water bottle for themselves.

External Fluid Administration (EFA): Method of fluid administration that involved a research aide squeezing the water bottle for participants.

Squirt: The act of squeezing the water bottle to dispense fluids into participants' mouths.

Recreationally active: Individuals partaking in physical activity at least four hours a week for a consecutive six months.

Exercise Protocol: The design of exercises/rests participants performed during data collection. The exercise protocol consisted of five 15 minute stations with 5 minute fluid breaks between each station.

Fluid Breaks: Rest periods between exercise stations which allowed participants to consumed fluids at will.

Perceptual Scales: Numerical scale with verbal cues corresponding to self-perception of thirst and fullness.

<u>Assumptions</u>

• We assume participants were in comparable physical shape based on our set exercise requirements for participation.

• The order of conditions was randomly assigned, so we assume our results were not influenced by the sequence of conditions performed.

• Participants in each exercise station performed the same fluid administration, as to assume participants did not influence each other's fluid consumption.

• The temperature of fluid was monitored throughout the duration of data collection to ensure consistent temperature. We assume by maintaining similar temperatures between testing days, the temperature of the fluid did not influence the volume consumed.

Delimitations

• The applicability of the results was limited to healthy, recreationally active individuals between the ages of 18 and 50.

• The applicability of the results was limited to individualized exercises, employing body weight as resistance, with no external motivation to influence exercise intensity.

• The applicability of the results was limited to individuals exercising in a euhydrated state.

• The applicability of the results was limited to the particular ambient conditions in which our participants exercised.

Limitations

• We were unable to control the environmental conditions between testing days in which participants exercised.

• Due to the nature of participants' schedules, not all participants performed all conditions within the same number of days.

• Since all conditions were scheduled within four days of each other, participants experienced associated muscle soreness. As a result of this soreness, participants were more apt to self-pace during the proceeding sessions.

• Participants were weighed wearing only shorts and a sports bra for females. Sweat had collected within the clothing of participants while exercising and were incorporated into post-exercise mass measurements. The additional sweat saturated within participants clothing may have influenced their percent dehydration, sweat loss, and sweat rate calculations

APPENDIX B: RELEVANT STUDY FORMS

Data Collection Forms

Familiarization-Demographic Sheet

2010 Hydration Study – Indiana State University – Dept of Applied Medicine and Rehabilitation

FAMILARIZATION-DEMOGRAPHIC DATA SHEET

Name ______________________________ Participant # ____________________

Age _________ Height __________ Weight _____________

☐ Informed Consent ☐ HHQ Cleared

Contact # _______________________

Name ______________________________ Participant # ____________________

Age _________ Height __________ Weight _____________

☐ Informed Consent ☐ HHQ Cleared

Contact # _______________________

Name ______________________________ Participant # ____________________

Age _________ Height __________ Weight _____________

☐ Informed Consent ☐ HHQ Cleared

Contact # _______________________

Name ______________________________ Participant # ____________________

Age _________ Height __________ Weight _____________

☐ Informed Consent ☐ HHQ Cleared

Contact # _______________________

Name ______________________________ Participant # ____________________

Age _________ Height __________ Weight _____________

☐ Informed Consent ☐ HHQ Cleared

Contact # _______________________

Health History Questionnaire

Health History Questionnaire Indiana State University Applied Medicine and Rehabilitation Department			
Subject No.	Height: (in cm) Weight: (in kg.) Age:		
Please answer the following questions to the best of your knowledge:			
1.	Do you regularly exercise 20-30 minutes at least twice a week?	Yes	No
2.	Are you currently under a doctor's care?	Yes	No
3.	**Women only:** Are you pregnant or do you think you might be?	Yes	No
4.	Do you have a pacemaker or automatic implanted cardiac defibrillator (AICD)?	Yes	No
5.	Have you ever donate blood? *If YES, have you ever been screened out of blood donation due to being told you have a low blood count?*	Yes	No
6.	Do you have, or suspect you have, a blood clotting disorder such as hemophilia?	Yes	No
7.	Do you have, or suspect that you have, any form of blood borne disease (hepatitis, HIV, AIDS)?	Yes	No
8.	Do you have, or suspect that you have, any circulatory problems or vascular (problems with your veins or arteries) disorders, conditions, disorders, or diseases?	Yes	No
9.	Do you have, or suspect that you have, any rheumatoid (joint) or muscular conditions, disorders or diseases?	Yes	No
10.	Do you have, or suspect that you have, a mitral valve prolapse, or any other disease, condition, or disorder that may be aggravated by participating in this study (see attachment for clarification)?	Yes	No
11.	Do you experience numbness, tingling, or decreased sensation in extremities, or have other neurological problems, conditions, disorders, or diseases?	Yes	No
12.	Do you have any problems, conditions, disorders or diseases that affect your ability to keep your balance?	Yes	No
13.	Are you currently taking any prescription medications? *If YES, please list all prescription medications.*	Yes	No
14.	Are you taking any over-the-counter medications or supplements? *If YES, please list below.*	Yes	No
15.	Do you have any other type of implanted magnetic device?	Yes	No
16.	Have you suffered from an upper or a lower extremity injury in the past 6 months?	Yes	No
17.	Have you ever been diagnosed with any obstruction disease or inflammatory disorder of the gastrointestinal (GI) tract (see attachment for clarification)?	Yes	No
18.	Do you have, or have you been diagnosed with, an impaired gag reflex?	Yes	No
19.	Have you been diagnosed with felinization (see attachment for clarification) of the esophagus?	Yes	No

Health History Questionnaire (Continued)

20.	Will you be undergoing Nuclear Magnetic Resonance/Magnetic Resonance Imaging scanning anytime throughout this study?	Yes	No
21.	Have you ever had any gastrointestinal (GI) surgery (this includes surgery of stomach or intestines)?	Yes	No
22.	Have you been diagnosed with any hypomotility disorder of the gastrointestinal (GI) tract (please see attachment for clarification)?	Yes	No

If you answered "YES" to any question or you are unsure about your answers, you will be asked for more detail to help the investigators better assess whether your condition increases your risk for participation. The questions and responses will be recorded on below. Your responses will be kept confidential and only reviewed by the research investigators and the Medical Director.

Is your annual medical physical on file with the fire department? YES / NO

I certify that all the information provided is correct.

______________________________ _______

Participant Signature Date

Current Health Questionnaire

Indiana State University
Department of Applied Medicine and Rehabilitation
CURRENT HEALTH QUESTIONNAIRE

1.	Have you experienced any vomiting or diarrhea in the last 48 hours?	Yes	No
2.	Have you consumed an excessive amount of alcohol in the last 48 hours?	Yes	No
3.	Have you had the cold or the flu within the last week?	Yes	No
4.	Have you had a gastrointestinal illness within the last week?	Yes	No
5.	Have you had any other general illness the investigator should know about in the last week?	Yes	No
6.	Have you being following habits of good health within the last week such as eating well, drinking fluids, and getting sufficient sleep?	Yes	No
7.	Do you feel dizzy or "unwell" in other ways that the primary investigators should be aware of?	Yes	No

Did you work yesterday? YES / NO

** If you answered yes to some of the questions above, the investigator may ask to delay you participation. Data collection will be delayed until all symptoms have resolved to ensure your safety during the study.

Dietary Protocol

Pre-testing Dietary Protocol

Indiana State University
More. From day one.

This Protocol is to be followed 24-hr prior to the first day of testing.

PLEASE avoid salty foods

- Peanuts
- Chips/pretzels
- Beef Jerky
- Pepperoni
- Etc.

PLEASE avoid foods containing fluids

- Oranges
- Watermelons
- Cucumbers
- Celery
- Etc.

PLEASE avoid excessive caffeine or alcohol consumption (no more than 6 beers, 6 glasses of wine, 6 shots/mixed drinks, or 6 cups of coffee)

*You will receive a call 36-hours prior to the first day of testing reminding you of this protocol.

Don't forget to wear sunscreen for each exercise session!

Hydration Data Sheet

2010 Hydration Study – Indiana State University – Dept of Applied Medicine and Rehabilitation

Pre/Post Data

Date ______________ Participant # _______________

Condition __________________

PRE		
Age		
Height		
Weight		
Osm		
USG		
Thirst		
RPE		
Fullness		

POST		
Weight		
Osm		
USG		
Thirst		
RPE		
Fullness		

- **Pre: Collect Urine then Weigh**
- **Post: Weigh then Collect Urine**
- **Perceptual Scale: Administer after Dynamic Warm-up**

Field Data Collection Sheet

2010 Hydration Study – Indiana State University – Dept of Applied Medicine and Rehabilitation

QUICK SHEET – FIELD DATA COLLECTION

DATE ____________ **BREAK #**______________ **CONDITION** ________________

EFA: You squirt into their mouth; **SA-M:** They squirt; **SA-MMon**: Mouth on

Participant # ______			
Thirst		RPE	
Fullness		# of Squirts	
Volume Consumed			

Participant # ______			
Thirst		RPE	
Fullness		# of Squirts	
Volume Consumed			

Participant # ______			
Thirst		RPE	
Fullness		# of Squirts	
Volume Consumed			

Participant # ______			
Thirst		RPE	
Fullness		# of Squirts	
Volume Consumed			

Participant # ______			
Thirst		RPE	
Fullness		# of Squirts	
Volume Consumed			

Station: ___________

Fluid Data Collection Sheet

2010 Hydration Study – Indiana State University – Dept of Applied Medicine and Rehabilitation

QUICK SHEET – FIELD DATA COLLECTION

DATE __________

Participant #	**Break #**	**Volume left over ____/1000mL**

Environmental Data Collection Sheet

2010 Hydration Study – Indiana State University – Dept of Applied Medicine and Rehabilitation

QUICK SHEET – FIELD DATA COLLECTION

DATE ____________________

Time	Water Temp (°C)	WBGT			

Thirst Scale

Thirst Scale

1 Not Thirsty At ALL

2

3 A Little Thirsty

4

5 Moderately Thirsty

6

7 Very Thirsty

8

9 Very, Very Thirsty

Fullness Scale

Perceived Sensation of Fullness

1 Not full at all

2 Somewhat full

3 Full

4 Very Full

5 Extremely Full

Dynamic Warm up Protocol

10-Minute Dynamic Warm-up Protocol

High Knee Stretch (~ 20 yards)
Take a step forward, grab your shin and pull the knee towards your chest.
Focus on standing up tall-perfect posture.
As you go to pull your knee towards your chest, lift your heel off the ground

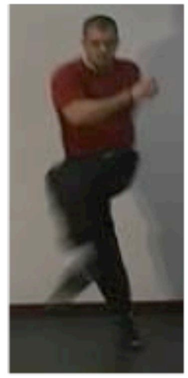
High Knee Skip (~ 20 yards, down and back)
Focus on bringing the knee up and toe pointed to the sky
Elbows at about 90 degrees
Looking for a smooth rhythmic motion

Butt Kicker (~20 yards, down and back)
Focus on bringing your heel to your butt
Ensure good contact (take your time)

Inverted Hamstring Stretch (~20 yards)
Reach both arms out to the side while attempting to lift 1 leg up to waist height
Try to stay as straight as possible reaching the back leg out with toe pointed towards the ground.
Bring the leg forward for 1 large step.

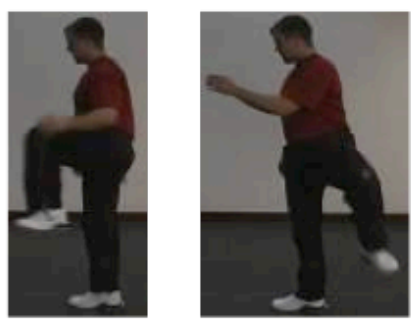
Dynamic Warm up Protocol (Continued)

Carioca (~20 feet, back and forth)
Lateral jog interchanging the back leg
in front and behind the leading leg

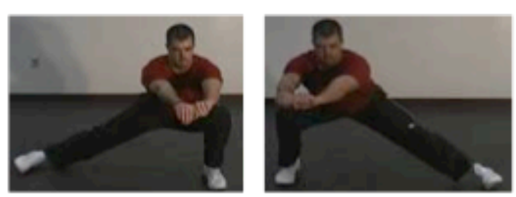


Hip Internal Rotation Jog (~20 yards)
Slow pace, as leg is brought forward, swing leg
towards the body with the knee flexed

Hip External Rotation Jog (~20 yards)
Slow pace, as leg is brought forward, swing leg
away from body with the knee flexed



Lateral lunge-Groin Stretch (~20 yards)
Step lateral, keeping knees flexed and back straight
Lean towards leading foot to stretch opposite groin
At 10 yards, turn to face to opposite direction
Perform same technique to stretch the other groin



Dynamic Warm up Protocol (Continued)

Superman Crawl (~20 yards)
Start in push up position
Walk leg to meet level of shoulders
Places stretch on opposite hip flexor
Progress forward to return to push up position
Repeat with opposite leg

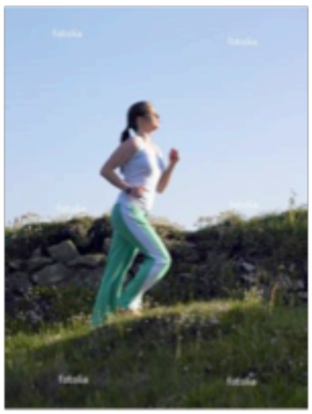
Lunge with Twist (~20 yards)
Begin with a forward lunge
Once in a lunge, twist towards the forward foot
Keep arms out at ~ 90 degrees

Inchworm (~20 yards)
Begin in push-up position
Drop hips to stretch the abdomen
Walk feet towards your hands
(legs should remain straight)
Once you have walked your feet in as far as you can,
Walk your hands away from your feet

25%, 50%, & 75% runs (~20 yards each)
Start a jog at 25% of your max sprint speed
Next jog will be 50% of your max sprint speed
Followed by 75%

Pictures of Exercise Protocol

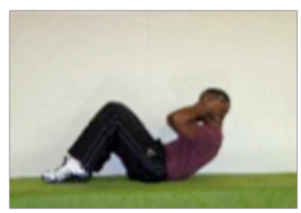
Exercises for Testing



Hill Jogging

Jumping Jacks

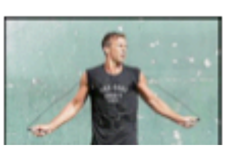
Up/downs



Crunches

Lunges

Mountain Climbers



Pictures of Exercise Protocol (Continued)

Jump Rope **Bear Crawl**

Push Ups

Ladder Agility Drills

Jogging in star formation

Institutional Review Board Informed Consent Form

CONSENT TO PARTICIPATE IN RESEARCH

Effect of fluid administration on hydration status and fluid consumption

You are asked to participate in a research study conducted by Dr. Susan Yeargin, Megan Finn, Dr. Lindsey Eberman, Dr. Matt Gage, and Dr. Brendon McDermott, from the Department of Applied Medicine and Rehabilitation at Indiana State University. A part of this study will be used for Megan Finn to complete her Master's Thesis. Your participation in this study is entirely voluntary. You may be included in the study if you regularly exercise 4-6 times a week for 45 or more minutes each time at a moderate or higher intensity. You cannot be in the study if you have had a joint or muscle injury or heat stroke recently. Please read the information below and ask questions about anything you do not understand, before deciding whether or not to participate.

PURPOSE OF THE STUDY

The purpose of this study is to look at different factors involved with fluid consumption during exercise, and determine if they have an effect on hydration status. We will conduct (3) separate days of testing, each day consisting of the same exercise but a different way to drink fluids.

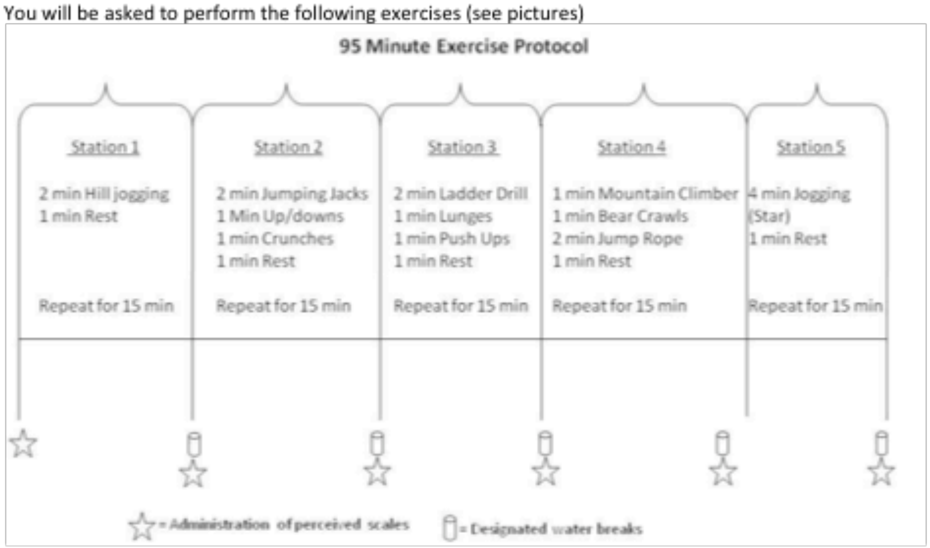
PROCEDURES

If you volunteer to participate in this study, you will be asked to do the following things:

- ➔ Day One:
  - This meeting will take about 1 hour. We will record your age, height, and weight. You will be asked to fill out a health history questionnaire
    - You will not be allowed to participate if:
      - Within the past 12 months suffered from a heat stroke
      - Currently suffering from an injury or illness
      - Under the age of 18 or over the age of 50
  - Researchers will discuss eating and drinking guidelines(to use 24-hours before day 1)
  - You will practice the warm up protocol, walk through the exercise protocol, and try each exercise.
- ➔ Days Two through Four:
  - You will receive a call 36 hours prior to the first testing session to remind you of the eating and drinking guidelines
  - You will be asked to arrive in shorts, t-shirt, socks and sneakers
  - Each session will take a little over 2 hours to complete (a total of 7 hours over 3 days)
  - You will provide a urine sample to determine your hydration status
    - You will go to a private bathroom and provide urine into a cup
  - Measure weight
    - You will be asked to wear just athletic shorts and a sports bra (if female)
  - You will be asked to perform the 10 minute warm up (Skipping, Stretching, and Jogging type movements- see pictures)
  - Next, you will be asked to provide your opinion about how hard or easy you feel you are working, how thirsty and full you feel at different times throughout exercise sessions.

Institutional Review Board Informed Consent Form (Continued)

➔ You will be asked to perform the following exercises (see pictures)



You are asked to do this for three days. Each day will consist of the same exercise; however, method of fluid consumption will be changed. You will complete each of the following fluid consumption methods but in random order.

1. You can only drink water every 15 minutes (during designated water breaks lasting 5 minutes) and a person will squirt the water in your mouth for you.
2. You can only drink water every 15 minutes (during designated water breaks lasting 5 minutes) and you will squirt the water in your own mouth.
3. You can drink water during the designated water breaks and you will squirt the water in your own mouth (by placing your mouth on the water bottle top).

- At the end of the exercise session, you will rest for at least 10 minutes to make sure you are feeling fine
- Next, your weight will be measured again (in just your athletic shorts and sports bra)
- Then, you will be asked to provide another urine sample
- On any testing day, if you are too dehydrated or feeling ill, we will reschedule your testing session

POTENTIAL RISKS AND DISCOMFORTS

We expect that any risk or discomfort associated with this study will be minor and we believe that they are not likely to happen. However, risks/discomforts are possible with exercising during this study, which may include joint or muscle injury(ligament sprain, muscle strain), soreness , sunburn, bee sting, scrape or broken bones from tripping or falling, thirst, heat illness (heat cramps, heat exhaustion, and heat stroke) due to exercising outdoors and/or feelings of embarrassment. There is a chance for injury during this exercise, but it may not be greater than the chance for an injury while working out in a gym or recreationally outdoors

If you get a physical injury or illness of any sort due to your participation in the study, we will provide initial, first-aid, treatment, and call advanced care if needed. Should you need or feel you need any care beyond the first-aid provided;

Institutional Review Board Informed Consent Form (Continued)

the researchers will not be responsible for any cost. You will be responsible for paying all costs associated with medical care beyond first aid. You may drop out at any time for any reason.

You may be at risk of embarrassment during this study since you will be asked to step on a scale wearing only shorts and a sports bra and then provide a urine sample. This risk is minimal, as the researchers will do their best to make these as quick as possible. Additionally, if you do not feel comfortable, we will allow you to wear your t-shirt during weight measurements and you will provide your urine sample in a private bathroom and return it to the researchers wrapped in a paper towel.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR SOCIETY

You may notice a small increase in cardiovascular fitness or strength after five days of exercising. It is not likely that you will benefit directly from participation in this study in any other way; however, the information gained from this study should help us learn more about the most favorable way to promote good hydration behaviors of exercising individuals.

COFIDENTIALITY

Any information that is gained in this study that can identify you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by assigning you a number. This number will be recorded on a master list that will be seen only by the researchers. The master list and all data sheets will be kept in a locked file cabinet by the primary investigator and then stored in a password-protected folder on a computer.

Information that can identify you individually will not be released to anyone outside of this study. Dr. Yeargin and co-investigators will use the information collected towards journal publications. Any information used for publication will be in summary format and you cannot be identified individually.

PARTICIPATION AND WITHDRAWAL

You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits to which you are otherwise entitled. You may also refuse to answer any questions you do not want to answer. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

The investigator may withdraw you from this research if circumstances arise which warrant doing so. Such circumstances include:

- Showing signs of health or injury risks with continued participation
- You are unable to complete the exercise protocol correctly (i.e. safe exercise form)
- You are too dehydrated to participate for that day

INCENTIVE

You will receive a total of $60.00 in Wal-Mart gift cards. The $60.00 will be divided into $20 gift cards. Eligible days include each of the condition testing days. If you choose to withdraw from the study you will still receive a $20 card for each day participated. There will be no direct cost to you for partaking in this study. However, there will be indirect costs. You will need to transport yourself to Deming Park and if you are injured and need care beyond first aid you will be responsible for any medical care costs.

Institutional Review Board Informed Consent Form (Continued)

IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about this research, please contact:

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Department of Applied Med & Rehab.
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812-237-3962
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Ms. Megan E. Finn
Co-investigator
Indiana State University
Terre Haute, IN 47809
978-808-8549
mfinn1@indstate.edu

RIGHTS OF RESEARCH PARTICIPANTS

If you have any questions about your rights as a research participant, you may contact the Indiana State University Institutional Review Board (IRB) by main at Indiana State University, Office of Sponsored Programs, Terre Haute, IN 47809, by phone at (812) 237-8217, or e-mail the IRB at irb@indstate.edu. You will be given the opportunity to discuss any questions about your rights as a research participant with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with ISU. The IRB has reviewed and approved this study.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____
Printed Name of Participant

____ ________________________
Signature of Participant Date

IRB Number: 10-164

Approval: 7/14/2010

Expiration Date: 7/14/2011

APPENDIX C: RAW DATA

Demographic Information

SubNum	Age	Ht (in)	Wt (kg)	Order of Conditions	Order of Stations
1	23	71.0	67.5	SAM, EFA, SAM-MON	2, 3, 4, 5, 1
2	20	63.5	66.5	EFA, SAM-MON, SAM	1, 2, 3, 4, 5
3	30		123.9	SAM, EFA, SAM-MON	2, 3, 4, 5, 1
4	24	68.0	68.4	SAM,SAM-MON, EFA	3, 4, 5, 1, 2
5	23	73.0	85.2	SAM, SAM-MON, EFA	3, 4, 5, 1, 2
6	31	72.0	78.6	SAM, SAM-MON, EFA	3, 4, 5, 1, 2
7	29	68.0	73.4	SAM, EFA, SAM-MON	2, 3, 4, 5, 1
10	43	67.5	78.6	SAM, EFA, SAM-MON	1, 2, 3, 4, 5
11	20		59.4	SAM, EFA, SAM-MON	1, 2, 3, 4, 5
12	34	70.0	77.0	EFA, SAM-MON, SAM	3, 4, 5, 1, 2
13	23	72.0	87.8	SAM, SAM-MON, EFA	1, 2, 3, 4, 5
14	24	73.0	70.8	EFA, SAM-MON, SAM	3, 4, 5, 1, 2
15	31	68.0	55.5	SAM, SAM-MON, EFA	1, 2, 3, 4, 5
16	43	75.0	88.8	SAM, SAM-MON, EFA	1, 2, 3, 4, 5
17	23	68.0	77.5	SAM, SAM-MON, EFA	1, 2, 3, 4, 5
18	27	68.0	75.5	EFA, SAM-MON, SAM	2, 3, 4, 5, 1
19	19	68.0	58.6	EFA, SAM-MON, SAM	3, 4, 5, 1, 2
20	49	72.0	75.9	SAM-MON, SAM, EFA	3, 4, 5, 1, 2
21	26	67.5	78.0	EFA, SAM-MON, SAM	3, 4, 5, 1, 2
22	26	67.0	67.0	EFA, SAM-MON, SAM	2, 3, 4, 5, 1
23	22	69.0	69.6	EFA, SAM-MON, SAM	2, 3, 4, 5, 1
24	49	63.0	54.7	EFA, SAM-MON, SAM	2, 3, 4, 5, 1

Waiting on a response for height

Environmental Data

					9/14/2010							9/16/2010
Time	Wtemp	WBGTO	WBGTRH	WBGTDr	WBGTWt	WBGTGb	Time	Wtemp	WBGTO	WBGTRH	WBGTDr	WBGTWt
5:31	3.4	23.7	53	26.7	21.5	29.2	5:30	4.37	20.2	58	23.2	18.5
5:59	4.87	23.7	57	26.5	22.1	28.3	6:03	4.39	19.6	60	22.8	18.1
6:34	4.77	23.2	64	25.6	21.9	26.5	6:33	2.59	19.7	63	22.6	18.4
7:05	4.42	22.8	68	25.1	21.5	26	7:05	2.33	19.6	65	22.4	18.4
							7:24	2.52	19.5	66	22.3	18.3

						9/17/2010						
WBGTGb	Time	Wtemp	WBGTO	WBGTRH	WBGTDr	WBGTWt	WBGTGb	Time	Wtemp	WBGTO	WBGTRH	WBGTDr
24.7	5:20	1.75	19.6	42	24.5	17.2	25.6	5:34	2.35	28.9	28	35.4
23.3	5:50	1.61	19.1	42	24.1	16.6	25.1	6:04	4.57	28.8	27	35.1
23.5	**6:05**	1.44	24.7	38	27.7	19.4	41.9	6:58	3.69	25.3	42	29
22.6	6:25	1.14	20	39	24.5	17.5	26.1	7:27	4.36	21.8	59	24.9
22.4	**6:40**	0.73	24	36	26.3	19.1	38.7					
	6:55	0.74	19.9	41	24	17.8	24.9					
	7:10	0.34	22.2	43	23.7	18.9	32.5					

Readings in the sun (highlighted)

9/21/2010							9/23/2010					
WBGTWt	WBGTGb	Time	Wtemp	WBGTO	WBGTRH	WBGTDr	WBGTWt	WBGTGb	Time	Wtemp	WBGTO	WBGTRH
23.6	43.4	5:20	3.08	28.5	42	33.7	24.7	41.3	5:24	2.88	22.7	43
23.3	43.9	5:53	3.73	26.7	39	32.5	23	36.6	5:56	2.8	24.4	41
22.3	33.5	6:24	4.68	25.6	40	31.6	22.6	33.6	6:26	3.5	22.7	38
20.6	23.8	6:59	4.58	25.4	43	30.6	22.7	32.2	6:56	3.34	20.5	40
		7:18	4.79	24.6	49	29.9	22.3	30.1	7:15	2.47	18.7	45

	9/24/2010							9/28/2010	
WBGTDr	WBGTWt	WBGTGb	Time	Wtemp	WBGTO	WBGTRH	WBGTDr	WBGTWt	WBGTGb
26.4	19.6	31.3	5:30	4.51	21.7	24	24.9	17.1	37.1
27.6	20.8	35.4	6:00	4.64	20.8	24	24.7	16.7	34.3
26.5	19.3	32.7	6:30	4.69	20.9	28	24.1	16.6	33.9
25.1	17.5	28.1	7:00	4.59	15.2	40	18.3	13.6	19.3
24.1	16.4	23.9	7:21	4.62	13.2	54	15.9	12.4	15.5

Urine Measures-Averages

SubNum	SAMPrAv	SAMPtAv	EFAPrAv	EFAPtAv	SMnPrAv	SMnPtAv
1	141	200	639.5	789	756	848.5
2	51.5	98.5	65.5	187	56	115
3	1079	1082				
4	699.5	644	392	344	844.5	665.5
5	1104.5	806.5	975.5	841	1022.5	922.5
6	762.5	793.5	859	819	924	849.5
7	786.5	436	1043.5	1037.5	789.5	1057
10	757	301.5	540.5	440	292	500
11	880.5	738.5				
12	297	722.5	1008.5	821.5	696	491
13	673.5	580.5	610.5	726.5	732.5	724.5
14	776.5	864	480.5	632	746.5	769.5
15	972.5	659.5	861	380	685.5	323
16	311	308	255	341	286	479.5
17	161	770.5	446	599.5	758	808.5
18	130.5	270.5	111	349.5	205	388.5
19	964.5	821.5	1189.5	1044.5	1089.5	1083
20	900	720.5	770.5	616.5	870.5	850.5
21			306	690.5		
22	1087	845.5	945	940.5	204	488.5
23	216.5	616.5	272.5	865.5	486.5	598.5
24	165.5	527.5	120.5	541.5	269.5	199

Urine Specific Gravity and Osmolality

SubNum	SAMPreU	SAMPstU	SAMDifU	SAMPreO	SAMPreO	SAMPreO	SAMPrAv	SAMPstO	SAMPstO	SAMPstO	SAMPtAv
1	1.004	1.007	0.003	142	140		141	198	202		200.000
2	1.002	1.005	0.003	53	50		51.5	100	97		98.500
3	1.027	1.031	0.004	1078	1080		1079	1083	1081		1082.000
4	1.020	1.021	0.001	701	698		699.5	645	643		644.000
5	1.031	1.027	-0.004	1104	1105		1104.5	807	806		806.500
6	1.019	1.024	0.005	761	764		762.5	792	795		793.500
7	1.020	1.014	-0.006	787	786		786.5	436	436		436.000
10	1.022	1.010	-0.012	756	758		757	301	302		301.500
11	1.021	1.029	0.008	882	879		880.5	737	740		738.500
12	1.010	1.023	0.013	296	298		297	721	724		722.500
13	1.018	1.020	0.002	672	675		673.5	580	581		580.500
14	1.021	1.025	0.004	778	775		776.5	865	863		864.000
15	1.025	1.020	-0.005	971	974		972.5	660	659		659.500
16	1.010	1.010	0.000	312	310		311	309	307		308.000
17	1.005	1.034	0.029	162	160		161	758	772	769	770.500
18	1.005	1.010	0.005	131	130		130.5	271	270		270.500
19	1.024	1.025	0.001	963	966		964.5	823	820		821.500
20	1.029	1.030	0.001	901	899		900	721	720		720.500
21											
22	1.030	1.023	-0.007	1087	1087		1087	847	844		845.500
23	1.006	1.016	0.010	218	215		216.5	618	615		616.500
24	1.006	1.020	0.014	167	164		165.5	528	527		527.500

Urine Specific Gravity and Osmolality (Continued)

SAMDifO	EFAPreU	EFAPstU	EFADifU	EFAPreO	EFAPreO	EFAPreO	EFAPrAv	EFAPstO	EFAPstO	EFAPstO	EFAPtAv	EFADifO
59.000	1.027	1.023	-0.004	641.000	638.000		639.500	790.000	797.000	788.000	789.000	149.500
47.000	1.004	1.008	0.004	79.000	65.000	66.000	65.500	188.000	186.000		187.000	121.500
3.000												
-55.500	1.014	1.012	-0.002	386.000	393.000	391.000	392.000	344.000	344.000		344.000	-48.000
-298.000	1.026	1.029	0.003	977.000	974.000		975.500	842.000	840.000		841	-134.500
31.000	1.022	1.024	0.002	865.000	858.000	860.000	859.000	824.000	818.000	820.000	819.000	-40.000
-350.500	1.027	1.028	0.001	1042.000	1045.000		1043.500	1036.000	1039.000		1037.500	-6.000
-455.500	1.016	1.015	-0.001	541.000	540.000		540.500	440.000	440.000		440.000	-100.500
-142.000												
425.500	1.026	1.025	-0.001	1008.000	1009.000		1008.500	820.000	823.000		821.500	-187.000
-93.000	1.018	1.022	0.004	609.000	612.000		610.500	725.000	728.000		726.500	116.000
87.500	1.015	1.020	0.005	482.000	479.000		480.500	641.000	643.000		632.000	151.500
-313.000	1.022	1.012	-0.010	862.000	860.000		861.000	381.000	379.000		380.000	-481.000
-3.000	1.008	1.011	0.003	256.000	254.000		255.000	341.000	341.000		341.000	86.000
609.500	1.014	1.016	0.002	447.000	445.000		446.000	598.000	601.000		599.500	153.500
140.000	1.014	1.015	0.001	112.000	110.000		111.000	348.000	351.000		349.500	238.500
-143.000	1.030	1.032	0.002	1188.000	1191.000		1189.500	1046.000	1043.000		1044.500	-145.000
-179.500	1.023	1.025	0.002	771.000	770.000		770.500	615.000	618.000		616.500	-154.000
	1.010	1.022	0.012	307.000	305.000		306.000	689.000	692.000		690.500	384.500
-241.500	1.025	1.028	0.003	945.000	945.000		945.000	942.000	939.000		940.500	-4.500
400.000	1.007	1.024	0.017	274.000	271.000		272.500	867.000	864.000		865.500	593.000
362.000	1.005	1.025	0.020	122.000	119.000		120.500	540.000	543.000		541.500	421.000

Urine Specific Gravity and Osmolality (Continued)

SMnPreU	SMnPstU	SMnDifU	SMnPreO	SMnPre0	SMnPre0	SMnPrAv	SMnPstO	SMnPstO	SMnPstO	SMnPtAv	SMnDifO
1.020	1.024	0.004	747.000	756.000	756.000	756.000	847.000	850.000		848.500	92.500
1.004	1.005	0.001	69.000	56.000	56.000	56.000	115.000	115.000		115.000	59.000
1.025	1.020	-0.005	843.000	846.000		844.500	667.000	664.000		665.500	-179.000
1.028	1.029	0.001	1022.000	1023.000		1022.500	924.000	921.000		922.500	-100.000
1.025	1.025	0.000	923.000	925.000		924.000	849.000	850.000		849.500	-74.500
1.021	1.030	0.009	789.000	790.000		789.500	1057.000	1057.000		1057.000	267.500
1.010	1.017	0.007	315.000	291.000	293.000	292.000	499.000	501.000		500.000	208.000
1.020	1.018	-0.002	697.000	695.000		696.000	492.000	490.000		491.000	-205.000
1.019	1.020	0.001	732.000	733.000		732.500	723.000	726.000		724.500	-8.000
1.024	1.025	0.001	746.000	747.000		746.500	768.000	771.000		769.500	23.000
1.019	1.010	-0.009	684.000	687.000		685.500	325.000	321.000		323.000	-362.500
1.010	1.015	0.005	287.000	285.000		286.000	480.000	479.000		479.500	193.500
1.021	1.025	0.004	757.000	759.000		758.000	808.000	809.000		808.500	50.500
1.007	1.014	0.007	206.000	204.000		205.000	387.000	390.000		388.500	183.500
1.030	1.034	0.004	1088.000	1091.000		1089.500	1084.000	1082.000		1083.000	-6.500
1.022	1.025	0.003	869.000	872.000		870.500	849.000	852.000		850.500	-20.000
1.006	1.015	0.009	205.000	203.000		204.000	487.000	490.000		488.500	284.500
1.012	1.015	0.003	486.000	487.000		486.500	597.000	600.000		598.500	112.000
1.010	1.010	0.000	271.000	268.000		269.500	199.000	199.000		199.000	-70.500

Body Mass and Sweat Measurements

SubNum	SAMPrWt	SAMPtWt	SAMDfWt	Deficit	SAMTotV	SAMSwLs	SAMSwRt	EFAPrWt	EFAPtWt	EFADfWt	Deficit	EFATotV
1	67.5	66.3	1.2	1200.0	225.0	1425.000	950.000	68.400	67.900	0.500	500.000	600.000
2	67.8	66.9	0.9	900.0	900.0	1800.000	1200.000	66.500	66.000	0.500	500.000	950.000
3	123.9	123.6	0.3	300.0	2350.0	2650.000	1766.667					
4	68.4	67.5	0.9	900.0	975.0	1875.000	1250.000	68.600	67.500	1.100	1100.000	700.000
5	85.2	84.1	1.1	1100.0	800.0	1900.000	1266.667	85.300	84.100	1.200	1200.000	850.000
6	78.6	78.2	0.4	400.0	1425.0	1825.000	1216.667	78.900	77.800	1.100	1100.000	1100.000
7	73.4	71.9	1.5	1500.0	775.0	2275.000	1516.667	73.400	72.100	1.300	1300.000	675.000
10	78.6	77.9	0.7	700.0	1050.0	1750.000	1166.667	78.500	77.700	0.800	800.000	700.000
11	59.4	59.8	-0.4	-400.0	1750.0	1350.000	900.000					
12	77.3	77.2	0.1	100.0	975.0	1075.000	716.667	77.000	75.700	1.300	1300.000	400.000
13	87.8	86.2	1.6	1600.0	925.0	2525.000	1683.333	88.200	86.900	1.300	1300.000	825.000
14	72.1	71.2	0.9	900.0	925.0	1825.000	1216.667	70.800	69.200	1.600	1600.000	450.000
15	55.5	54.6	0.9	900.0	475.0	1375.000	916.667	55.800	55.300	0.500	500.000	525.000
16	88.8	86.6	2.2	2200.0	750.0	2950.000	1966.667	89.300	87.600	1.700	1700.000	425.000
17	77.5	76.4	1.1	1100.0	1425.0	2525.000	1683.333	77.600	76.800	0.800	800.000	800.000
18	75.0	74.0	1.0	1000.0	925.0	1925.000	1283.333	75.500	73.900	1.600	1600.000	425.000
19	58.0	57.0	1.0	1000.0	250.0	1250.000	833.333	58.600	57.300	1.300	1300.000	350.000
20	75.6	74.5	1.1	1100.0	1150.0	2250.000	1500.000	76.500	75.000	1.500	1500.000	400.000
21							0.000	78.000	75.500	2.500	2500.000	100.000
22	68.0	67.1	0.9	900.0	875.0	1775.000	1183.333	67.000	65.000	2.000	2000.000	475.000
23	69.9	69.1	0.8	800.0	875.0	1675.000	1116.667	69.600	68.200	1.400	1400.000	450.000
24	55.2	54.7	0.5	500.0	775.0	1275.000	850.000	54.700	53.900	0.800	800.000	375.000

EFASwLs	EFASwRt	SMnPrWt	SMnPtWt	SMnDfWt	Deficit	SMnTotV	SMnSwLs	SMnSwRt
1100.000	733.333	67.900	67.100	0.800	800.000	700.000	1500.000	1000.000
1450.000	966.667	66.800	66.800	0.000	0.000	1450.000	1450.000	966.667
	0.000							0.000
1800.000	1200.000	68.800	68.000	0.800	800.000	1075.000	1875.000	1250.000
2050.000	1366.667	85.600	84.500	1.100	1100.000	850.000	1950.000	1300.000
2200.000	1466.667	78.600	78.400	0.200	200.000	1500.000	1700.000	1133.333
1975.000	1316.667	73.600	72.700	0.900	900.000	1400.000	2300.000	1533.333
1500.000	1000.000	78.600	78.200	0.400	400.000	1450.000	1850.000	1233.333
	0.000							0.000
1700.000	1133.333	77.400	77.900	-0.500	-500.000	2175.000	1675.000	1116.667
2125.000	1416.667	90.100	88.900	1.200	1200.000	1275.000	2475.000	1650.000
2050.000	1366.667	72.000	70.800	1.200	1200.000	700.000	1900.000	1266.667
1025.000	683.333	55.400	54.800	0.600	600.000	500.000	1100.000	733.333
2125.000	1416.667	88.400	86.700	1.700	1700.000	700.000	2400.000	1600.000
1600.000	1066.667	77.200	77.100	0.100	100.000	1775.000	1875.000	1250.000
2025.000	1350.000	75.600	74.700	0.900	900.000	1250.000	2150.000	1433.333
1650.000	1100.000	58.200	57.300	0.900	900.000	400.000	1300.000	866.667
1900.000	1266.667	75.900	74.900	1.000	1000.000	1575.000	2575.000	1716.667
2600.000	1733.333							0.000
2475.000	1650.000	68.000	66.200	1.800	1800.000	525.000	2325.000	1550.000
1850.000	1233.333	69.900	68.800	1.100	1100.000	425.000	1525.000	1016.667
1175.000	783.333	55.800	55.200	0.600	600.000	425.000	1025.000	683.333

Fluid Measures

SubNum	SAM-B1	SAMSqts	SAMVSqt	SAM-B2	SAMSqts	SAMVSqt	SAM-B3	SAMSqts	SAMVSqt	SAM-B4	SAMSqts	SAMVSqt
1	0	0	0.000	50	1	50.000	50	1	50.000	25	1	25.000
2	100	6	16.667	200	13	16.667	200	10	20.000	125	11	11.364
3	150	3	50.000	500	8	62.500	550	10	55.000	500	10	50.000
4	125	7	17.857	150	5	30.000	150	9	16.667	200	7	28.571
5	50	2	25.000	125	5	25.000	125	5	25.000	150	6	25.000
6	100	4	25.000	200	6	33.333	400	10	40.000	275	9	30.556
7	0	0	0.000	50	3	16.667	100	4	25.000	150	5	30.000
10	200	8	25.000	150	12	12.500	150	10	15.000	100	10	10.000
11	500	9	55.556	200	7	28.571	350	10	35.000	300	9	33.333
12	0	0	0.000	250	4	62.500	375	7	53.571	100	3	33.333
13	200	8	25.000	300	13	23.077	150	6	25.000	100	3	33.333
14	100	4	25.000	200	5	40.000	200	4	50.000	175	5	35.000
15	100	9	11.111	150	9	16.667	50	4	12.500	50	7	7.143
16	0	0	0.000	100	6	16.667	150	6	25.000	100	6	16.667
17	100	7	14.286	350	13	26.923	150	6	25.000	325	10	32.500
18	75	3	25.000	150	7	21.429	150	6	25.000	175	6	29.167
19	25	1	25.000	50	3	16.667	50	2	25.000	50	1	50.000
20	50	1	50.000	100	3	33.333	250	5	50.000	225	5	45.000
21												
22	75	6	12.500	50	9	5.556	150	13	11.538	250	13	19.231
23	75	3	25.000	100	6	16.667	150	4	37.500	200	8	25.000
24	50	1	50.000	100	6	16.667	100	3	33.333	125	5	25.000

Fluid Measures (Continued)

SAM-B5	SAMSqts	SAMVSqt	SAM-B6	SAMSqts	SAMVSqt	SAMTotV	SAMTotV	EFA-B1	EFASqts	EFAVSqt	EFA-B2	EFASqts
50	1	50.000	50	1	50.000	225	225	50	1	50.000	100	5
150	12	12.500	125	12	10.417	900	900	100	5	20.000	150	6
350	10	35.000	300	10	30.000	2350	2350					
200	6	33.333	150	6	25.000	975	975	50	3	16.667	100	10
100	6	16.667	250	7	35.714	800	800	50	4	12.500	100	10
250	8	31.250	200	9	22.222	1425	1425	50	3	16.667	200	13
200	7	28.571	275	7	39.286	775	775	0	0	0.000	50	3
200	5	40.000	250	10	25.000	1050	1050	50	3	16.667	100	8
200	6	33.333	200	6	33.333	1750	1750					
200	5	40.000	50	3	16.667	975	975	0	0	0.000	0	0
150	5	30.000	25	2	12.500	925	925	100	4	25.000	100	5
150	4	37.500	100	4	25.000	925	925	0	0	0.000	50	4
75	5	15.000	50	5	10.000	475	475	100	5	20.000	100	4
200	6	33.333	200	7	28.571	750	750	50	2	25.000	50	3
300	10	30.000	200	6	33.333	1425	1425	50	4	12.500	100	6
200	6	33.333	175	6	29.167	925	925	0	0	0.000	50	5
50	3	16.667	25	2	12.500	250	250	0	0	0.000	50	3
300	5	60.000	225	5	45.000	1150	1150	50	1	50.000	50	2
								0	0	0.000	0	0
200	10	20.000	150	10	15.000	875	875	0	0	0.000	50	6
100	3	33.333	250	10	25.000	875	875	0	0	0.000	50	6
200	7	28.571	200	8	25.000	775	775	0	0	0.000	50	5

Fluid Measures (Continued)

EFAVSqt	EFA-B3	EFASqts	EFAVSqt	EFA-B4	EFASqts	EFAVSqt	EFA-B5	EFASqts	EFAVSqt	EFA-B6	EFASqts	EFAVSqt
20.000	150	2	75.000	150	3	50.000	100	3	33.333	50	2	25.000
25.000	150	8	18.750	150	7	21.429	200	9	22.222	200	9	22.222
10.000	150	10	15.000	100	6	16.667	150	9	16.667	150	9	16.667
10.000	100	9	10.000	250	12	20.833	150	8	18.750	200	10	20.000
15.385	250	15	16.667	300	11	27.273	200	10	20.000	100	5	20.000
16.667	150	2	75.000	250	3	83.333	125	3	41.667	100	3	33.333
12.500	100	7	14.286	100	6	16.667	200	10	20.000	150	10	15.000
0.000	100	5	20.000	125	7	17.857	100	8	12.500	75	5	15.000
20.000	200	9	22.222	175	7	25.000	100	7	14.286	150	6	25.000
12.500	100	6	16.667	100	6	16.667	100	6	16.667	100	6	16.667
25.000	50	3	16.667	125	4	31.250	75	4	18.750	75	4	18.750
16.667	75	4	18.750	100	4	25.000	100	4	25.000	50	3	16.667
16.667	150	7	21.429	100	7	14.286	150	6	25.000	250	5	50.000
10.000	100	9	11.111	125	10	12.500	100	7	14.286	50	5	10.000
16.667	50	5	10.000	100	7	14.286	100	5	20.000	50	6	8.333
25.000	50	3	16.667	100	3	33.333	75	3	25.000	75	3	25.000
0.000	0	0	0.000	25	2	12.500	75	3	25.000	0	0	0.000
8.333	75	9	8.333	125	11	11.364	125	8	15.625	100	9	11.111
8.333	50	8	6.250	150	9	16.667	100	7	14.286	100	8	12.500
10.000	100	8	12.500	75	8	9.375	100	7	14.286	50	7	7.143

Fluid Measures (Continued)

EFATotV	EFATotV	SMn-B1	SMnSqts	SMnVSqt	SMn-B2	SMnSqts	SMnVSqt	SMn-B3	SMnSqts	SMnVSqt	SMn-B4	SMnSqts
600	600	100	2	50.000	100	1	100.000	150	3	50.000	100	2
950	950	100	5	20.000	200	12	16.667	250	10	25.000	300	12
700	700	125	7	17.857	150	4	37.500	300	5	60.000	150	3
850	850	200	5	40.000	200	6	33.333	250	6	41.667	50	4
1100	1100	150	4	37.500	300	4	75.000	400	6	66.667	250	6
675	675	50	2	25.000	100	1	100.000	450	3	150.000	400	2
700	700	200	6	33.333	200	8	25.000	250	7	35.714	250	12
400	400	100	1	100.000	600	2	300.000	775	3	258.333	400	1
825	825	150	5	30.000	50	8	6.250	275	8	34.375	250	8
450	450	75	4	18.750	125	5	25.000	150	6	25.000	150	2
525	525	100	7	14.286	100	7	14.286	50	5	10.000	50	5
425	425	100	4	25.000	100	5	20.000	150	7	21.429	100	8
800	800	200	6	33.333	275	7	39.286	400	9	44.444	300	6
425	425	0	0	0.000	250	6	50.000	200	4	50.000	200	5
350	350	0	0	0.000	100	4	25.000	100	2	50.000	100	5
400	400	50	3	16.667	275	4	68.750	300	4	75.000	400	3
100	100											
475	475	0	0	0.000	100	4	25.000	75	15	5.000	50	6
450	450	75	5	15.000	100	6	16.667	50	4	12.500	0	0
375	375	25	4	6.250	150	4	37.500	50	5	10.000	50	3

Fluid Measures (Continued)

SMnVSqt	SMn-B5	SMnSqts	SMnVSqt	SMn-B6	SMnSqts	SMnVSqt	SMnTotV	SMnTotV
50.000	150	2	75.000	100	2	50.000	700	700
25.000	250	15	16.667	350	9	38.889	1450	1450
50.000	200	5	40.000	150	3	50.000	1075	1075
12.500	50	4	12.500	100	5	20.000	850	850
41.667	250	6	41.667	150	6	25.000	1500	1500
200.000	150	2	75.000	250	3	83.333	1400	1400
20.833	200	8	25.000	350	9	38.889	1450	1450
400.000	200	1	200.000	100	2	50.000	2175	2175
31.250	200	5	40.000	350	8	43.750	1275	1275
75.000	100	4	25.000	100	3	33.333	700	700
10.000	100	5	20.000	100	7	14.286	500	500
12.500	150	8	18.750	100	7	14.286	700	700
50.000	350	6	58.333	250	7	35.714	1775	1775
40.000	200	6	33.333	400	4	100.000	1250	1250
20.000	50	3	16.667	50	2	25.000	400	400
133.333	300	3	100.000	250	4	62.500	1575	1575
8.333	100	5	20.000	200	11	18.182	525	525
0.000	50	5	10.000	150	4	37.500	425	425
16.667	100	2	50.000	50	4	12.500	425	425

Perceptual Measures

SubNum	SAMTB1	SAMTB2	SAMTB3	SAMTB4	SAMTB5	SAMTB6	SAMFB1	SAMFB2	SAMFB3	SAMFB4	SAMFB5	SAMFB6
1	2	3	4	5	3	3	4	3	3	3	3	3
2	6	8	5	5	6	3	2	2	1	1	1	1
3	4	7	7	7	4	7	3	3	3	3	3	3
4	3	4	2	4	7	3	1	1	4	2	1	2
5	3	3	3	3	4	5	1	1	1	1	2	2
6	2	5	6	6	7	5	1	1	1	1	2	2
7	3	5	6	7	7	6	2	2	2	2	2	2
10	4	4	5	6	5	6	2	2	1	1	2	1
11	5	4	4	6	6	3	2	2	2	2	1	1
12	1	3	3	3	5	5	4	5	4	3	3	3
13	6	9	7	5	4	6	1	1	1	3	3	4
14	3	3	6	6	8	6	2	2	2	2	2	2
15	5	6	4	3	4	3	1	1	2	2	1	2
16	2	5	5	5	4	5	1	1	1	1	1	1
17	5	8	7	2	8	2	1	1	2	2	2	2
18	3	3	4	2	4	5	3	3	3	3	3	4
19	1	2	2	2	3	2	2	2	2	2	2	2
20	3	3	5	3	5	3	3	3	3	5	3	5
21												
22	5	5	3	4	5	6	2	1	1	1	1	1
23	3	4	4	2	4	7	1	1	1	1	1	1
24	2	5	3	5	5	6	1	1	1	2	2	2

Perceptual Measures (Continued)

SAMEB1	SAMEB2	SAMEB3	SAMEB4	SAMEB5	SAMEB6	EFATB1	EFATB2	EFATB3	EFATB4	EFATB5	EFATB6	EFAFB1
11	11	12	13	14	18	5	5	6	6	5	5	1
9	16	15	15	16	15	6	6	7	5	6	7	3
11	14	16	17	16	17							
10	13	13	15	17	13	1	5	5	1	3	3	2
11	13	15	15	15	15	4	7	5	3	5	7	1
9	14	16	13	17	14	1	5	6	4	5	5	2
11	14	16	16	14	18	2	3	3	3	3	4	1
11	13	15	16	14	17	3	4	5	5	6	5	2
12	14	13	15	13	13							
7	12	12	12	17	13	2	4	6	8	8	8	4
8	17	15	15	15	15	3	4	7	3	7	8	2
7	12	15	15	17	16	7	7	8	8	9	9	2
6	18	15	14	16	13	3	4	3	3	3	2	2
6	15	16	13	15	16	1	4	5	3	3	3	1
9	17	15	15	16	15	4	7	7	5	7	6	2
6	13	15	9	12	16	4	6	7	3	5	7	3
7	16	16	16	16	16	3	3	6	7	9	9	2
8	13	15	13	13	15	2	3	4	3	4	3	1
						2	2	3	8	3	3	2
7	8	11	10	13	13	2	5	7	3	7	5	5
6	9	11	11	15	14	3	5	7	6	5	6	2
6	8	11	11	14	13	3	7	7	5	7	6	1

Perceptual Measures (Continued)

EFAFB2	EFAFB3	EFAFB4	EFAFB5	EFAFB6	EFAEB1	EFAEB2	EFAEB3	EFAEB4	EFAEB5	EFAEB6	SMnTB1	SMnTB2
1	1	1	1	1	9	15	17	17	13	17	7	5
3	2	2	1	1	7	14	16	16	16	16	4	5
1	1	1	1	1	7	16	12	12	12	11	1	3
1	1	1	1	1	7	16	14	11	13	16	3	3
1	1	1	1	1	7	17	12	12	14	11	1	4
1	1	1	1	1	8	14	16	17	15	18	3	2
1	1	1	1	1	7	13	15	16	17	16	3	6
2	2	3	3	2	7	10	12	14	17	13	1	2
2	1	1	2	1	9	13	13	13	14	15	2	4
2	2	1	1	1	7	13	16	18	18	18	4	5
3	2	2	1	2	7	19	13	14	15	14	3	6
1	1	1	1	1	8	13	13	12	14	13	2	3
2	2	2	2	1	6	17	14	15	17	15	3	6
2	4	4	3	3	6	11	13	11	12	16	3	5
1	1	1	1	1	13	15	13	14	18	18	1	2
2	2	1	1	2	9	13	13	13	13	13	4	5
2	2	2	2	2	8	11	11	11	11	10		
5	4	3	4	4	6	11	12	11	11	14	2	2
3	2	2	1	3	6	13	13	12	13	14	3	4
1	1	1	1	2	6	13	12	11	11	14	4	6

Perceptual Measures (Continued)

SMnTB3	SMnTB4	SMnTB5	SMnTB6	SMnFB1	SMnFB2	SMnFB3	SMnFB4	SMnFB5	SMnFB6	SMnEB1	SMnEB2	SMnEB3	SMnEB4	SMnEB5	SMnEB6
6	4	6	3	1	3	2	2	1	2	9	14	13	17	16	12
6	5	5	6	2	2	2	1	1	1	8	14	17	15	17	14
3	2	1	3	1	1	1	1	1	1	9	12	12	12	16	12
5	2	4	5	1	1	1	1	1	1	7	10	12	16	18	15
4	5	5	5	2	1	1	1	2	2	8	12	12	12	16	12
3	4	4	2	2	3	2	2	2	3	9	18	15	16	14	14
5	5	6	7	1	1	1	1	1	1	9	15	16	16	17	17
3	5	5	8	5	5	4	3	2	3	8	12	11	15	17	16
3	3	6	4	2	2	3	1	2	2	6	14	13	14	15	14
7	7	8	9	3	5	4	3	2	3	8	11	14	16	17	17
4	3	5	4	2	2	2	2	2	1	6	18	15	14	15	14
3	5	4	4	1	1	1	2	1	1	6	13	14	15	12	13
5	5	7	6	2	3	2	2	2	2	6	15	14	15	15	14
4	3	4	7	2	4	2	3	2	3	6	12	11	12	12	15
5	3	5	8	2	2	1	1	1	2	6	17	17	16	17	17
5	5	5	5	3	5	1	1	2	2	9	13	13	13	15	15
7	2	7	9	2	1	1	1	1	1	6	8	11	11	11	15
4	5	5	5	2	3	3	3	3	3	6	8	11	12	13	13
6	6	6	6	2	2	2	2	2	2	6	10	11	12	12	12

APPENDIX D: STATISTICAL ANALYSIS

General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	preusg
2	postusg

Between-Subjects Factors

		N
condition	1	19
	2	19

Descriptive Statistics

	condition	Mean	Std. Deviation	N
preusg	1	1.01616	.009703	19
	2	1.01805	.008120	19
	Total	1.01711	.008877	38
postusg	1	1.01916	.008036	19
	2	1.02074	.006999	19
	Total	1.01995	.007476	38

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.119	4.863[a]	1.000	36.000	.034
	Wilks' Lambda	.881	4.863[a]	1.000	36.000	.034
	Hotelling's Trace	.135	4.863[a]	1.000	36.000	.034
	Roy's Largest Root	.135	4.863[a]	1.000	36.000	.034
time * condition	Pillai's Trace	.000	.015[a]	1.000	36.000	.903
	Wilks' Lambda	1.000	.015[a]	1.000	36.000	.903
	Hotelling's Trace	.000	.015[a]	1.000	36.000	.903
	Roy's Largest Root	.000	.015[a]	1.000	36.000	.903

a. Exact statistic

c. Design: Intercept + condition
Within Subjects Design: time

Multivariate Tests[c]

Effect		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
time	Pillai's Trace	.119	4.863	.574
	Wilks' Lambda	.119	4.863	.574
	Hotelling's Trace	.119	4.863	.574
	Roy's Largest Root	.119	4.863	.574
time * condition	Pillai's Trace	.000	.015	.052
	Wilks' Lambda	.000	.015	.052
	Hotelling's Trace	.000	.015	.052
	Roy's Largest Root	.000	.015	.052

b. Computed using alpha = .05

c. Design: Intercept + condition
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept + condition
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + condition
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	.000	1	.000	4.863
	Greenhouse-Geisser	.000	1.000	.000	4.863
	Huynh-Feldt	.000	1.000	.000	4.863
	Lower-bound	.000	1.000	.000	4.863
time * condition	Sphericity Assumed	4.737E-7	1	4.737E-7	.015
	Greenhouse-Geisser	4.737E-7	1.000	4.737E-7	.015
	Huynh-Feldt	4.737E-7	1.000	4.737E-7	.015
	Lower-bound	4.737E-7	1.000	4.737E-7	.015
Error(time)	Sphericity Assumed	.001	36	3.156E-5	
	Greenhouse-Geisser	.001	36.000	3.156E-5	
	Huynh-Feldt	.001	36.000	3.156E-5	
	Lower-bound	.001	36.000	3.156E-5	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	.034	.119	4.863	.574
	Greenhouse-Geisser	.034	.119	4.863	.574
	Huynh-Feldt	.034	.119	4.863	.574
	Lower-bound	.034	.119	4.863	.574
time * condition	Sphericity Assumed	.903	.000	.015	.052
	Greenhouse-Geisser	.903	.000	.015	.052
	Huynh-Feldt	.903	.000	.015	.052
	Lower-bound	.903	.000	.015	.052

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.
time	Linear	.000	1	.000	4.863	.034
time * condition	Linear	4.737E-7	1	4.737E-7	.015	.903
Error(time)	Linear	.001	36	3.156E-5		

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	.119	4.863	.574
time * condition	Linear	.000	.015	.052

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	78.842	1	78.842	748968.601	.000	1.000
condition	5.732E-5	1	5.732E-5	.544	.465	.015
Error	.004	36	.000			

Tests of Between-Subjects Effects

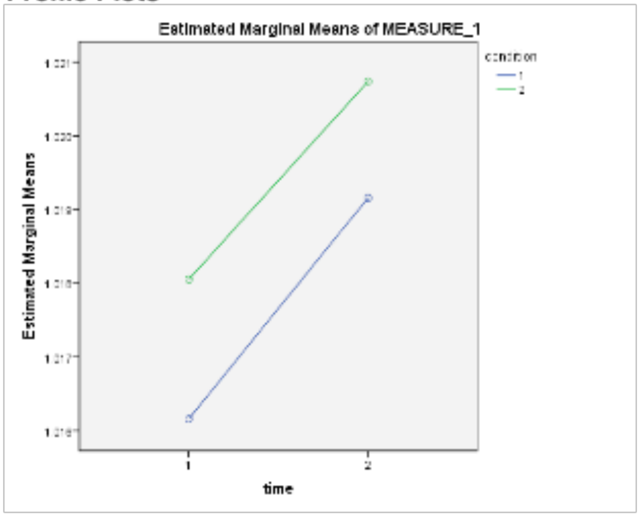
Measure:MEASURE_1

Transformed Variable:Average

Source	Noncent. Parameter	Observed Power[a]
Intercept	748968.601	1.000
condition	.544	.111

a. Computed using alpha = .05

Profile Plots



General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	vol1
2	vol2
3	vol3
4	vol4
5	vol5
6	vol6

Between-Subjects Factors

		N
condition	1	19
	2	19

Descriptive Statistics

	condition	Mean	Std. Deviation	N
vol1	1	75.0000	59.51190	19
	2	36.8421	36.67464	19
	Total	55.9211	52.45146	38
vol2	1	148.6842	85.17697	19
	2	78.9474	45.07953	19
	Total	113.8158	75.93947	38
vol3	1	163.1579	94.41649	19
	2	113.1579	54.24252	19
	Total	138.1579	80.06265	38
vol4	1	152.6316	79.88479	19
	2	142.1053	61.26708	19
	Total	147.3684	70.42090	38
vol5	1	172.3684	73.07470	19
	2	123.6842	40.37471	19
	Total	148.0263	63.24063	38
vol6	1	155.2632	83.57421	19
	2	109.2105	59.04949	19
	Total	132.2368	75.09181	38

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.684	13.883[a]	5.000	32.000	.000
	Wilks' Lambda	.316	13.883[a]	5.000	32.000	.000
	Hotelling's Trace	2.169	13.883[a]	5.000	32.000	.000
	Roy's Largest Root	2.169	13.883[a]	5.000	32.000	.000
time * condition	Pillai's Trace	.200	1.601[a]	5.000	32.000	.188
	Wilks' Lambda	.800	1.601[a]	5.000	32.000	.188
	Hotelling's Trace	.250	1.601[a]	5.000	32.000	.188
	Roy's Largest Root	.250	1.601[a]	5.000	32.000	.188

a. Exact statistic

c. Design: Intercept + condition
Within Subjects Design: time

Multivariate Tests[c]

Effect		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
time	Pillai's Trace	.684	69.413	1.000
	Wilks' Lambda	.684	69.413	1.000
	Hotelling's Trace	.684	69.413	1.000
	Roy's Largest Root	.684	69.413	1.000
time * condition	Pillai's Trace	.200	8.003	.485
	Wilks' Lambda	.200	8.003	.485
	Hotelling's Trace	.200	8.003	.485
	Roy's Largest Root	.200	8.003	.485

b. Computed using alpha = .05

c. Design: Intercept + condition

Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.340	36.799	14	.001

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept + condition

Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.726	.840	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + condition

Within Subjects Design: time

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	232489.035	5	46497.807	15.864
	Greenhouse-Geisser	232489.035	3.629	64061.442	15.864
	Huynh-Feldt	232489.035	4.198	55374.723	15.864
	Lower-bound	232489.035	1.000	232489.035	15.864
time * condition	Sphericity Assumed	17850.877	5	3570.175	1.218
	Greenhouse-Geisser	17850.877	3.629	4918.739	1.218
	Huynh-Feldt	17850.877	4.198	4251.759	1.218
	Lower-bound	17850.877	1.000	17850.877	1.218
Error(time)	Sphericity Assumed	527576.754	180	2930.982	
	Greenhouse-Geisser	527576.754	130.650	4038.103	
	Huynh-Feldt	527576.754	151.145	3490.537	
	Lower-bound	527576.754	36.000	14654.910	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	.000	.306	79.321	1.000
	Greenhouse-Geisser	.000	.306	57.574	1.000
	Huynh-Feldt	.000	.306	66.606	1.000
	Lower-bound	.000	.306	15.864	.972
time * condition	Sphericity Assumed	.302	.033	6.090	.426
	Greenhouse-Geisser	.307	.033	4.421	.354
	Huynh-Feldt	.305	.033	5.114	.385
	Lower-bound	.277	.033	1.218	.189

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.
time	Linear	132166.353	1	132166.353	26.864	.000
	Quadratic	97042.607	1	97042.607	23.205	.000
	Cubic	2339.181	1	2339.181	1.813	.187
	Order 4	939.850	1	939.850	.483	.492
	Order 5	1.044	1	1.044	.000	.983

time * condition	Linear	541.353	1	541.353	.110	.742
	Quadratic	414.317	1	414.317	.099	.755
	Cubic	6272.295	1	6272.295	4.860	.034
	Order 4	7633.929	1	7633.929	3.921	.055
	Order 5	2988.983	1	2988.983	1.291	.263
Error(time)	Linear	177113.722	36	4919.826		
	Quadratic	150549.029	36	4181.917		
	Cubic	46457.968	36	1290.499		
	Order 4	70086.936	36	1946.859		
	Order 5	83369.100	36	2315.808		

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	.427	26.864	.999
	Quadratic	.392	23.205	.997
	Cubic	.048	1.813	.259
	Order 4	.013	.483	.104
	Order 5	.000	.000	.050
time * condition	Linear	.003	.110	.062
	Quadratic	.003	.099	.061
	Cubic	.119	4.860	.574
	Order 4	.098	3.921	.487
	Order 5	.035	1.291	.198

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure:MEASURE_1

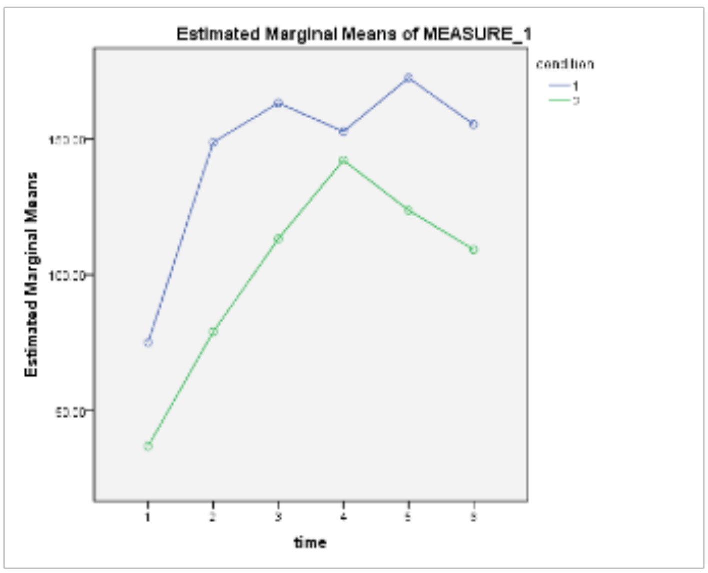
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3426326.754	1	3426326.754	282.030	.000	.887
condition	109649.123	1	109649.123	9.025	.005	.200
Error	437357.456	36	12148.818			

Tests of Between-Subjects Effects		
Measure:MEASURE_1		
Transformed Variable:Average		
Source	Noncent. Parameter	Observed Power[a]
Intercept	282.030	1.000
condition	9.025	.832

a. Computed using alpha = .05

Profile Plots

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General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	Sq1
2	sq2
3	sq3
4	sq4
5	sq5
6	sq6

Between-Subjects Factors

		N
condition	1	19
	2	19

Descriptive Statistics

	condition	Mean	Std. Deviation	N
Sq1	1	3.68	3.146	19
	2	1.89	1.941	19
	Total	2.79	2.733	38
sq2	1	6.79	3.720	19
	2	5.47	3.080	19
	Total	6.13	3.434	38
sq3	1	6.05	3.118	19
	2	6.79	3.259	19
	Total	6.42	3.168	38
sq4	1	6.37	3.253	19
	2	6.89	2.787	19
	Total	6.63	2.999	38
sq5	1	6.00	2.646	19
	2	6.53	2.318	19
	Total	6.26	2.468	38
sq6	1	6.32	3.074	19
	2	6.05	2.527	19
	Total	6.18	2.779	38

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.690	14.277[a]	5.000	32.000	.000
	Wilks' Lambda	.310	14.277[a]	5.000	32.000	.000
	Hotelling's Trace	2.231	14.277[a]	5.000	32.000	.000
	Roy's Largest Root	2.231	14.277[a]	5.000	32.000	.000
time * condition	Pillai's Trace	.205	1.646[a]	5.000	32.000	.176
	Wilks' Lambda	.795	1.646[a]	5.000	32.000	.176
	Hotelling's Trace	.257	1.646[a]	5.000	32.000	.176
	Roy's Largest Root	.257	1.646[a]	5.000	32.000	.176

a. Exact statistic

c. Design: Intercept + condition
Within Subjects Design: time

Multivariate Tests[c]

Effect		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
time	Pillai's Trace	.690	71.385	1.000
	Wilks' Lambda	.690	71.385	1.000
	Hotelling's Trace	.690	71.385	1.000
	Roy's Largest Root	.690	71.385	1.000
time * condition	Pillai's Trace	.205	8.230	.498
	Wilks' Lambda	.205	8.230	.498
	Hotelling's Trace	.205	8.230	.498
	Roy's Largest Root	.205	8.230	.498

b. Computed using alpha = .05
c. Design: Intercept + condition
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.352	35.650	14	.001

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept + condition
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.687	.790	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + condition
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	402.368	5	80.474	21.740
	Greenhouse-Geisser	402.368	3.437	117.061	21.740
	Huynh-Feldt	402.368	3.950	101.871	21.740
	Lower-bound	402.368	1.000	402.368	21.740
time * condition	Sphericity Assumed	54.000	5	10.800	2.918
	Greenhouse-Geisser	54.000	3.437	15.710	2.918
	Huynh-Feldt	54.000	3.950	13.672	2.918
	Lower-bound	54.000	1.000	54.000	2.918
Error(time)	Sphericity Assumed	666.298	180	3.702	
	Greenhouse-Geisser	666.298	123.741	5.385	
	Huynh-Feldt	666.298	142.192	4.686	
	Lower-bound	666.298	36.000	18.508	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	.000	.377	108.700	1.000
	Greenhouse-Geisser	.000	.377	74.725	1.000
	Huynh-Feldt	.000	.377	85.868	1.000
	Lower-bound	.000	.377	21.740	.995
time * condition	Sphericity Assumed	.015	.075	14.588	.843
	Greenhouse-Geisser	.030	.075	10.029	.725
	Huynh-Feldt	.024	.075	11.524	.771
	Lower-bound	.096	.075	2.918	.383

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.
time	Linear	167.753	1	167.753	23.165	.000
	Quadratic	176.222	1	176.222	42.331	.000
	Cubic	48.843	1	48.843	24.334	.000
	Order 4	6.015	1	6.015	2.025	.163
	Order 5	3.536	1	3.536	1.663	.205
time * condition	Linear	22.750	1	22.750	3.142	.085
	Quadratic	23.865	1	23.865	5.733	.022
	Cubic	1.032	1	1.032	.514	.478
	Order 4	2.741	1	2.741	.922	.343
	Order 5	3.613	1	3.613	1.700	.201
Error(time)	Linear	260.696	36	7.242		
	Quadratic	149.866	36	4.163		
	Cubic	72.259	36	2.007		
	Order 4	106.959	36	2.971		
	Order 5	76.518	36	2.126		

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	.392	23.165	.997
	Quadratic	.540	42.331	1.000
	Cubic	.403	24.334	.998
	Order 4	.053	2.025	.283
	Order 5	.044	1.663	.241
time * condition	Linear	.080	3.142	.407
	Quadratic	.137	5.733	.644
	Cubic	.014	.514	.107
	Order 4	.025	.922	.155
	Order 5	.045	1.700	.245

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	7503.789	1	7503.789	224.441	.000	.862
condition	3.947	1	3.947	.118	.733	.003
Error	1203.596	36	33.433			

Tests of Between-Subjects Effects

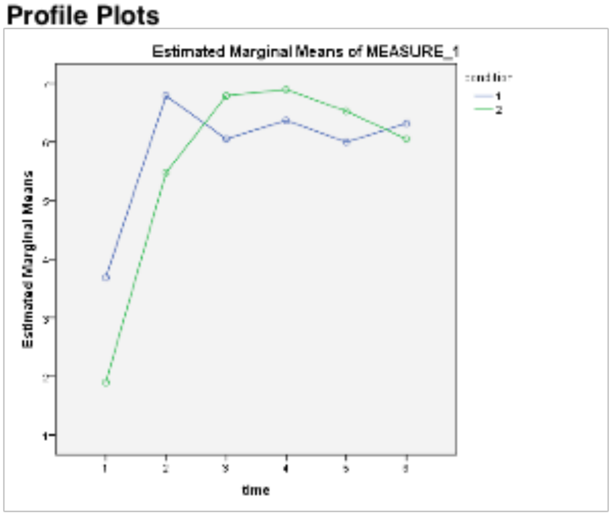
Measure:MEASURE_1

Transformed Variable:Average

Source	Noncent. Parameter	Observed Power[a]
Intercept	224.441	1.000
condition	.118	.063

a. Computed using alpha = .05

Profile Plots



General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	vpsq1
2	vpsq2
3	vpsq3
4	vpsq4
5	vpsq5
6	vpsq6

Between-Subjects Factors

		N
condition	1	19
	2	19

Descriptive Statistics

	condition	Mean	Std. Deviation	N
vpsq1	1	19.6011	14.49252	19
	2	13.5053	15.60082	19
	Total	16.5532	15.16980	38
vpsq2	1	25.2799	13.86292	19
	2	14.6694	6.60627	19
	Total	19.9746	11.98463	38
vpsq3	1	29.7426	13.43001	19
	2	21.3315	19.42071	19
	Total	25.5370	17.01163	38
vpsq4	1	26.9402	10.97257	19
	2	24.4097	17.17504	19
	Total	25.6750	14.27307	38
vpsq5	1	31.0558	11.95353	19
	2	20.4381	7.28341	19
	Total	25.7469	11.14744	38
vpsq6	1	25.5462	11.46275	19
	2	19.3891	9.92248	19
	Total	22.4676	11.02509	38

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.418	4.596[a]	5.000	32.000	.003
	Wilks' Lambda	.582	4.596[a]	5.000	32.000	.003
	Hotelling's Trace	.718	4.596[a]	5.000	32.000	.003
	Roy's Largest Root	.718	4.596[a]	5.000	32.000	.003
time * condition	Pillai's Trace	.156	1.185[a]	5.000	32.000	.338
	Wilks' Lambda	.844	1.185[a]	5.000	32.000	.338
	Hotelling's Trace	.185	1.185[a]	5.000	32.000	.338
	Roy's Largest Root	.185	1.185[a]	5.000	32.000	.338

a. Exact statistic

c. Design: Intercept + condition
Within Subjects Design: time

Multivariate Tests[c]

Effect		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
time	Pillai's Trace	.418	22.980	.945
	Wilks' Lambda	.418	22.980	.945
	Hotelling's Trace	.418	22.980	.945
	Roy's Largest Root	.418	22.980	.945
time * condition	Pillai's Trace	.156	5.924	.364
	Wilks' Lambda	.156	5.924	.364
	Hotelling's Trace	.156	5.924	.364
	Roy's Largest Root	.156	5.924	.364

b. Computed using alpha = .05

c. Design: Intercept + condition
 Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.298	41.278	14	.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept + condition
 Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.704	.811	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + condition
 Within Subjects Design: time

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	2714.650	5	542.930	5.116
	Greenhouse-Geisser	2714.650	3.520	771.159	5.116
	Huynh-Feldt	2714.650	4.057	669.138	5.116
	Lower-bound	2714.650	1.000	2714.650	5.116
time * condition	Sphericity Assumed	462.092	5	92.418	.871
	Greenhouse-Geisser	462.092	3.520	131.268	.871
	Huynh-Feldt	462.092	4.057	113.902	.871
	Lower-bound	462.092	1.000	462.092	.871
Error(time)	Sphericity Assumed	19104.129	180	106.134	
	Greenhouse-Geisser	19104.129	126.728	150.749	
	Huynh-Feldt	19104.129	146.050	130.806	
	Lower-bound	19104.129	36.000	530.670	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	.000	.124	25.578	.984
	Greenhouse-Geisser	.001	.124	18.008	.943
	Huynh-Feldt	.001	.124	20.753	.964
	Lower-bound	.030	.124	5.116	.595
time * condition	Sphericity Assumed	.502	.024	4.354	.308
	Greenhouse-Geisser	.472	.024	3.065	.254
	Huynh-Feldt	.484	.024	3.533	.274
	Lower-bound	.357	.024	.871	.149

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.
time	Linear	1200.556	1	1200.556	10.411	.003
	Quadratic	1391.721	1	1391.721	7.880	.008
	Cubic	27.367	1	27.367	.336	.566
	Order 4	24.863	1	24.863	.238	.629
	Order 5	70.143	1	70.143	1.333	.256
time * condition	Linear	4.185	1	4.185	.036	.850
	Quadratic	1.574	1	1.574	.009	.925
	Cubic	29.842	1	29.842	.366	.549
	Order 4	296.233	1	296.233	2.830	.101
	Order 5	130.259	1	130.259	2.475	.124
Error(time)	Linear	4151.180	36	115.311		
	Quadratic	6357.805	36	176.606		
	Cubic	2932.201	36	81.450		
	Order 4	3768.568	36	104.682		
	Order 5	1894.375	36	52.622		

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	.224	10.411	.881
	Quadratic	.180	7.880	.780
	Cubic	.009	.336	.087
	Order 4	.007	.238	.076
	Order 5	.036	1.333	.203
time * condition	Linear	.001	.036	.054
	Quadratic	.000	.009	.051
	Cubic	.010	.366	.091
	Order 4	.073	2.830	.374
	Order 5	.064	2.475	.334

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	117062.735	1	117062.735	228.060	.000	.864
condition	3124.516	1	3124.516	6.087	.019	.145
Error	18478.721	36	513.298			

Tests of Between-Subjects Effects

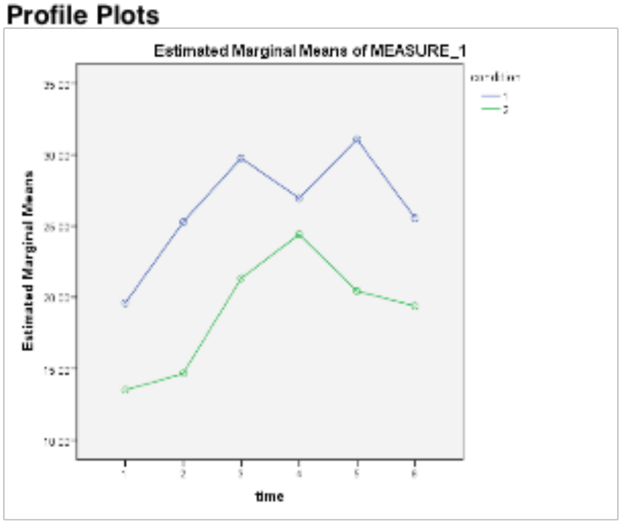
Measure:MEASURE_1

Transformed Variable:Average

Source	Noncent. Parameter	Observed Power[a]
Intercept	228.060	1.000
condition	6.087	.670

a. Computed using alpha = .05

Profile Plots

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General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	preusg
2	postusg

Between-Subjects Factors

		N
condition	1	19
	2	19

Descriptive Statistics

	condition	Mean	Std. Deviation	N
preusg	1	1.01616	.009703	19
	2	1.01805	.008120	19
	Total	1.01711	.008877	38
postusg	1	1.01916	.008036	19
	2	1.02074	.006999	19
	Total	1.01995	.007476	38

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.119	4.863[a]	1.000	36.000	.034
	Wilks' Lambda	.881	4.863[a]	1.000	36.000	.034
	Hotelling's Trace	.135	4.863[a]	1.000	36.000	.034
	Roy's Largest Root	.135	4.863[a]	1.000	36.000	.034
time * condition	Pillai's Trace	.000	.015[a]	1.000	36.000	.903
	Wilks' Lambda	1.000	.015[a]	1.000	36.000	.903
	Hotelling's Trace	.000	.015[a]	1.000	36.000	.903
	Roy's Largest Root	.000	.015[a]	1.000	36.000	.903

a. Exact statistic

c. Design: Intercept + condition
Within Subjects Design: time

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	SAMTSq - EFATSq	1.57895	12.17153	2.79234
Pair 2	SAMTvpsq - EFATvpsq	7.46991	11.11170	2.54920

Paired Samples Test

		Paired Differences 95% Confidence Interval of the Difference				
		Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	SAMTSq - EFATSq	-4.28754	7.44544	.565	18	.579
Pair 2	SAMTvpsq - EFATvpsq	2.11424	12.82558	2.930	18	.009

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SAMDfWt	.9895	19	.45448	.10426
	EFADfWt	1.1737	19	.43056	.09878
Pair 2	SAMDehy	1.3558	19	.52977	.12154
	EFADehyd	1.6152	19	.58576	.13438
Pair 3	SAMSwLs	1856.5789	19	484.03986	111.04636
	EFASwLs	1777.6316	19	394.57209	90.52105
Pair 4	SAMSwRt	1237.7193	19	322.69324	74.03091
	EFASwRt	1185.0877	19	263.04806	60.34736

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	SAMDfWt & EFADfWt	19	.237	.329
Pair 2	SAMDehy & EFADehyd	19	.053	.831
Pair 3	SAMSwLs & EFASwLs	19	.510	.026
Pair 4	SAMSwRt & EFASwRt	19	.510	.026

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	SAMDfWt - EFADfWt	-.18421	.54697	.12548
Pair 2	SAMDehy - EFADehyd	-.25937	.76888	.17639
Pair 3	SAMSwLs - EFASwLs	78.94737	441.84455	101.36609
Pair 4	SAMSwRt - EFASwRt	52.63158	294.56303	67.57739

Paired Samples Test

		Paired Differences				
		95% Confidence Interval of the Difference				
		Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	SAMDfWt - EFADfWt	-.44784	.07942	-1.468	18	.159
Pair 2	SAMDehy - EFADehyd	-.62996	.11122	-1.470	18	.159
Pair 3	SAMSwLs - EFASwLs	-134.01489	291.90963	.779	18	.446
Pair 4	SAMSwRt - EFASwRt	-89.34326	194.60642	.779	18	.446

General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	TBrk1
2	TBrk2
3	TBrk3
4	TBrk4
5	TBrk5
6	TBrk6

Between-Subjects Factors

		N
Conditions	1	19
	2	19

Descriptive Statistics

	Conditions	Mean	Std. Deviation	N
TBrk1	1	3.2632	1.52177	19
	2	3.1053	1.62941	19
	Total	3.1842	1.55712	38
TBrk2	1	4.6316	1.94966	19
	2	4.9474	1.39338	19
	Total	4.7895	1.67909	38
TBrk3	1	4.4211	1.53897	19
	2	5.8421	1.42451	19
	Total	5.1316	1.63031	38
TBrk4	1	4.1053	1.59495	19
	2	4.4211	1.92399	19
	Total	4.2632	1.75043	38
TBrk5	1	5.1579	1.57280	19
	2	5.6316	1.94966	19
	Total	5.3947	1.76359	38
TBrk6	1	4.5789	1.57465	19
	2	5.6842	2.08307	19
	Total	5.1316	1.90548	38

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.738	18.033[a]	5.000	32.000	.000
	Wilks' Lambda	.262	18.033[a]	5.000	32.000	.000
	Hotelling's Trace	2.818	18.033[a]	5.000	32.000	.000
	Roy's Largest Root	2.818	18.033[a]	5.000	32.000	.000
time * Conditions	Pillai's Trace	.273	2.399[a]	5.000	32.000	.059
	Wilks' Lambda	.727	2.399[a]	5.000	32.000	.059
	Hotelling's Trace	.375	2.399[a]	5.000	32.000	.059
	Roy's Largest Root	.375	2.399[a]	5.000	32.000	.059

a. Exact statistic

c. Design: Intercept + Conditions
Within Subjects Design: time

Multivariate Tests[c]

Effect		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
time	Pillai's Trace	.738	90.164	1.000
	Wilks' Lambda	.738	90.164	1.000
	Hotelling's Trace	.738	90.164	1.000
	Roy's Largest Root	.738	90.164	1.000
time * Conditions	Pillai's Trace	.273	11.996	.684
	Wilks' Lambda	.273	11.996	.684
	Hotelling's Trace	.273	11.996	.684
	Roy's Largest Root	.273	11.996	.684

b. Computed using alpha = .05

c. Design: Intercept + Conditions

Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.362	34.667	14	.002

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept + Conditions

Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.687	.789	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + Conditions

Within Subjects Design: time

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	126.772	5	25.354	15.266
	Greenhouse-Geisser	126.772	3.433	36.928	15.266
	Huynh-Feldt	126.772	3.944	32.141	15.266
	Lower-bound	126.772	1.000	126.772	15.266
time * Conditions	Sphericity Assumed	15.947	5	3.189	1.920
	Greenhouse-Geisser	15.947	3.433	4.645	1.920
	Huynh-Feldt	15.947	3.944	4.043	1.920
	Lower-bound	15.947	1.000	15.947	1.920
Error(time)	Sphericity Assumed	298.947	180	1.661	
	Greenhouse-Geisser	298.947	123.587	2.419	
	Huynh-Feldt	298.947	141.993	2.105	
	Lower-bound	298.947	36.000	8.304	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	.000	.298	76.331	1.000
	Greenhouse-Geisser	.000	.298	52.408	1.000
	Huynh-Feldt	.000	.298	60.214	1.000
	Lower-bound	.000	.298	15.266	.967
time * Conditions	Sphericity Assumed	.093	.051	9.602	.641
	Greenhouse-Geisser	.121	.051	6.593	.523
	Huynh-Feldt	.111	.051	7.575	.564
	Lower-bound	.174	.051	1.920	.271

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.
time	Linear	61.968	1	61.968	19.191	.000
	Quadratic	17.301	1	17.301	12.486	.001
	Cubic	17.000	1	17.000	11.980	.001
	Order 4	16.129	1	16.129	13.856	.001
	Order 5	14.374	1	14.374	12.993	.001

time * Conditions	Linear	4.385	1	4.385	1.358	.252
	Quadratic	1.018	1	1.018	.735	.397
	Cubic	4.896	1	4.896	3.450	.071
	Order 4	1.430	1	1.430	1.228	.275
	Order 5	4.219	1	4.219	3.814	.059
Error(time)	Linear	116.247	36	3.229		
	Quadratic	49.883	36	1.386		
	Cubic	51.087	36	1.419		
	Order 4	41.906	36	1.164		
	Order 5	39.824	36	1.106		

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	.348	19.191	.989
	Quadratic	.258	12.486	.930
	Cubic	.250	11.980	.920
	Order 4	.278	13.856	.952
	Order 5	.265	12.993	.939
time * Conditions	Linear	.036	1.358	.206
	Quadratic	.020	.735	.133
	Cubic	.087	3.450	.440
	Order 4	.033	1.228	.190
	Order 5	.096	3.814	.476

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	4928.070	1	4928.070	552.409	.000	.939
Conditions	19.105	1	19.105	2.142	.152	.056
Error	321.158	36	8.921			

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Noncent. Parameter	Observed Power[a]
Intercept	552.409	1.000
Conditions	2.142	.297

a. Computed using alpha = .05

General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	FBrk1
2	FBrk2
3	FBrk3
4	FBrk4
5	FBrk5
6	FBrk6

Between-Subjects Factors

		N
Conditions	1	19
	2	19

Descriptive Statistics

	Conditions	Mean	Std. Deviation	N
FBrk1	1	1.8421	1.01451	19
	2	2.0526	1.07877	19
	Total	1.9474	1.03838	38
FBrk2	1	1.7895	1.08418	19
	2	1.8421	1.06787	19
	Total	1.8158	1.06175	38
FBrk3	1	1.8947	1.04853	19
	2	1.6842	.94591	19
	Total	1.7895	.99071	38
FBrk4	1	2.0000	1.05409	19
	2	1.5789	.90159	19
	Total	1.7895	.99071	38
FBrk5	1	1.9474	.77986	19
	2	1.4737	.90483	19
	Total	1.7105	.86705	38
FBrk6	1	2.2105	1.13426	19
	2	1.5789	.90159	19
	Total	1.8947	1.06007	38

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.269	2.360[a]	5.000	32.000	.062
	Wilks' Lambda	.731	2.360[a]	5.000	32.000	.062
	Hotelling's Trace	.369	2.360[a]	5.000	32.000	.062
	Roy's Largest Root	.369	2.360[a]	5.000	32.000	.062
time * Conditions	Pillai's Trace	.201	1.610[a]	5.000	32.000	.186
	Wilks' Lambda	.799	1.610[a]	5.000	32.000	.186
	Hotelling's Trace	.252	1.610[a]	5.000	32.000	.186
	Roy's Largest Root	.252	1.610[a]	5.000	32.000	.186

a. Exact statistic

c. Design: Intercept + Conditions
Within Subjects Design: time

Multivariate Tests[c]

Effect		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
time	Pillai's Trace	.269	11.802	.676
	Wilks' Lambda	.269	11.802	.676
	Hotelling's Trace	.269	11.802	.676
	Roy's Largest Root	.269	11.802	.676
time * Conditions	Pillai's Trace	.201	8.052	.488
	Wilks' Lambda	.201	8.052	.488
	Hotelling's Trace	.201	8.052	.488
	Roy's Largest Root	.201	8.052	.488

b. Computed using alpha = .05

c. Design: Intercept + Conditions

Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.249	47.428	14	.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept + Conditions

Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.668	.765	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + Conditions

Within Subjects Design: time

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	1.351	5	.270	.844
	Greenhouse-Geisser	1.351	3.340	.404	.844
	Huynh-Feldt	1.351	3.825	.353	.844
	Lower-bound	1.351	1.000	1.351	.844
time * Conditions	Sphericity Assumed	5.035	5	1.007	3.146
	Greenhouse-Geisser	5.035	3.340	1.508	3.146
	Huynh-Feldt	5.035	3.825	1.316	3.146
	Lower-bound	5.035	1.000	5.035	3.146
Error(time)	Sphericity Assumed	57.614	180	.320	
	Greenhouse-Geisser	57.614	120.240	.479	
	Huynh-Feldt	57.614	137.695	.418	
	Lower-bound	57.614	36.000	1.600	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	.520	.023	4.220	.298
	Greenhouse-Geisser	.483	.023	2.819	.241
	Huynh-Feldt	.495	.023	3.229	.258
	Lower-bound	.364	.023	.844	.145
time * Conditions	Sphericity Assumed	.010	.080	15.731	.873
	Greenhouse-Geisser	.023	.080	10.508	.752
	Huynh-Feldt	.018	.080	12.034	.795
	Lower-bound	.085	.080	3.146	.408

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.
time	Linear	.182	1	.182	.285	.597
	Quadratic	.847	1	.847	4.640	.038
	Cubic	.047	1	.047	.144	.706
	Order 4	.241	1	.241	.849	.363
	Order 5	.034	1	.034	.201	.656

time * Conditions	Linear	4.886	1	4.886	7.651	.009
	Quadratic	.080	1	.080	.439	.512
	Cubic	.005	1	.005	.016	.900
	Order 4	.060	1	.060	.212	.648
	Order 5	.004	1	.004	.022	.882
Error(time)	Linear	22.989	36	.639		
	Quadratic	6.573	36	.183		
	Cubic	11.803	36	.328		
	Order 4	10.199	36	.283		
	Order 5	6.050	36	.168		

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	time	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	.008	.285	.081
	Quadratic	.114	4.640	.554
	Cubic	.004	.144	.066
	Order 4	.023	.849	.146
	Order 5	.006	.201	.072
time * Conditions	Linear	.175	7.651	.768
	Quadratic	.012	.439	.099
	Cubic	.000	.016	.052
	Order 4	.006	.212	.073
	Order 5	.001	.022	.052

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	759.018	1	759.018	173.441	.000	.828
Conditions	3.439	1	3.439	.786	.381	.021
Error	157.544	36	4.376			

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Noncent. Parameter	Observed Power[a]
Intercept	173.441	1.000
Conditions	.786	.139

a. Computed using alpha = .05

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	vol1	55.9211	38	52.45146	8.50875
	vol2	113.8158	38	75.93947	12.31901
Pair 2	vol1	55.9211	38	52.45146	8.50875
	vol3	138.1579	38	80.06265	12.98788
Pair 3	vol1	55.9211	38	52.45146	8.50875
	vol4	147.3684	38	70.42090	11.42378
Pair 4	vol1	55.9211	38	52.45146	8.50875
	vol5	148.0263	38	63.24063	10.25899
Pair 5	vol1	55.9211	38	52.45146	8.50875
	vol6	132.2368	38	75.09181	12.18150
Pair 6	vol2	113.8158	38	75.93947	12.31901
	vol3	138.1579	38	80.06265	12.98788
Pair 7	vol2	113.8158	38	75.93947	12.31901
	vol4	147.3684	38	70.42090	11.42378
Pair 8	vol2	113.8158	38	75.93947	12.31901
	vol5	148.0263	38	63.24063	10.25899
Pair 9	vol2	113.8158	38	75.93947	12.31901
	vol6	132.2368	38	75.09181	12.18150
Pair 10	vol3	138.1579	38	80.06265	12.98788
	vol4	147.3684	38	70.42090	11.42378
Pair 11	vol3	138.1579	38	80.06265	12.98788
	vol5	148.0263	38	63.24063	10.25899
Pair 12	vol3	138.1579	38	80.06265	12.98788
	vol6	132.2368	38	75.09181	12.18150
Pair 13	vol4	147.3684	38	70.42090	11.42378
	vol5	148.0263	38	63.24063	10.25899
Pair 14	vol4	147.3684	38	70.42090	11.42378
	vol6	132.2368	38	75.09181	12.18150
Pair 15	vol5	148.0263	38	63.24063	10.25899
	vol6	132.2368	38	75.09181	12.18150

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	vol1 & vol2	38	.624	.000
Pair 2	vol1 & vol3	38	.226	.172
Pair 3	vol1 & vol4	38	.183	.272
Pair 4	vol1 & vol5	38	.289	.079
Pair 5	vol1 & vol6	38	.216	.192
Pair 6	vol2 & vol3	38	.564	.000
Pair 7	vol2 & vol4	38	.361	.026
Pair 8	vol2 & vol5	38	.548	.000
Pair 9	vol2 & vol6	38	.127	.447
Pair 10	vol3 & vol4	38	.483	.002
Pair 11	vol3 & vol5	38	.612	.000
Pair 12	vol3 & vol6	38	.256	.120
Pair 13	vol4 & vol5	38	.598	.000
Pair 14	vol4 & vol6	38	.409	.011
Pair 15	vol5 & vol6	38	.583	.000

Paired Samples Test

		Paired Differences				
					95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	vol1 - vol2	-57.89474	59.58904	9.66662	-77.48117	-38.30831
Pair 2	vol1 - vol3	-82.23684	85.20799	13.82256	-110.24401	-54.22967
Pair 3	vol1 - vol4	-91.44737	79.75391	12.93779	-117.66183	-65.23291
Pair 4	vol1 - vol5	-92.10526	69.53156	11.27951	-114.95972	-69.25081
Pair 5	vol1 - vol6	-76.31579	81.77659	13.26592	-103.19509	-49.43649
Pair 6	vol2 - vol3	-24.34211	72.94177	11.83272	-48.31747	-.36674
Pair 7	vol2 - vol4	-33.55263	82.87004	13.44330	-60.79134	-6.31393
Pair 8	vol2 - vol5	-34.21053	67.13768	10.89117	-56.27813	-12.14292
Pair 9	vol2 - vol6	-18.42105	99.77749	16.18605	-51.21710	14.37499
Pair 10	vol3 - vol4	-9.21053	76.98303	12.48830	-34.51422	16.09317
Pair 11	vol3 - vol5	-9.86842	64.86459	10.52243	-31.18888	11.45204
Pair 12	vol3 - vol6	5.92105	94.69621	15.36175	-25.20482	37.04692
Pair 13	vol4 - vol5	-.65789	60.26037	9.77552	-20.46499	19.14920
Pair 14	vol4 - vol6	15.13158	79.17213	12.84341	-10.89165	41.15481
Pair 15	vol5 - vol6	15.78947	64.04735	10.38985	-5.26237	36.84131

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	vol1 - vol2	-5.989	37	.000
Pair 2	vol1 - vol3	-5.949	37	.000
Pair 3	vol1 - vol4	-7.068	37	.000
Pair 4	vol1 - vol5	-8.166	37	.000
Pair 5	vol1 - vol6	-5.753	37	.000
Pair 6	vol2 - vol3	-2.057	37	.047
Pair 7	vol2 - vol4	-2.496	37	.017
Pair 8	vol2 - vol5	-3.141	37	.003
Pair 9	vol2 - vol6	-1.138	37	.262
Pair 10	vol3 - vol4	-.738	37	.465
Pair 11	vol3 - vol5	-.938	37	.354
Pair 12	vol3 - vol6	.385	37	.702
Pair 13	vol4 - vol5	-.067	37	.947
Pair 14	vol4 - vol6	1.178	37	.246
Pair 15	vol5 - vol6	1.520	37	.137

T-Test

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Sq1	2.79	38	2.733	.443
	sq2	6.13	38	3.434	.557
Pair 2	Sq1	2.79	38	2.733	.443
	sq3	6.42	38	3.168	.514
Pair 3	Sq1	2.79	38	2.733	.443
	sq4	6.63	38	2.999	.487
Pair 4	Sq1	2.79	38	2.733	.443
	sq5	6.26	38	2.468	.400
Pair 5	Sq1	2.79	38	2.733	.443
	sq6	6.18	38	2.779	.451
Pair 6	sq2	6.13	38	3.434	.557
	sq3	6.42	38	3.168	.514
Pair 7	sq2	6.13	38	3.434	.557
	sq4	6.63	38	2.999	.487
Pair 8	sq2	6.13	38	3.434	.557
	sq5	6.26	38	2.468	.400
Pair 9	sq2	6.13	38	3.434	.557
	sq6	6.18	38	2.779	.451
Pair 10	sq3	6.42	38	3.168	.514
	sq4	6.63	38	2.999	.487
Pair 11	sq3	6.42	38	3.168	.514
	sq5	6.26	38	2.468	.400
Pair 12	sq3	6.42	38	3.168	.514
	sq6	6.18	38	2.779	.451
Pair 13	sq4	6.63	38	2.999	.487
	sq5	6.26	38	2.468	.400
Pair 14	sq4	6.63	38	2.999	.487
	sq6	6.18	38	2.779	.451
Pair 15	sq5	6.26	38	2.468	.400
	sq6	6.18	38	2.779	.451

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Sq1 & sq2	38	.683	.000
Pair 2	Sq1 & sq3	38	.313	.055
Pair 3	Sq1 & sq4	38	.310	.058
Pair 4	Sq1 & sq5	38	.245	.138
Pair 5	Sq1 & sq6	38	.233	.159
Pair 6	sq2 & sq3	38	.603	.000
Pair 7	sq2 & sq4	38	.566	.000
Pair 8	sq2 & sq5	38	.576	.000
Pair 9	sq2 & sq6	38	.462	.004
Pair 10	sq3 & sq4	38	.799	.000
Pair 11	sq3 & sq5	38	.753	.000
Pair 12	sq3 & sq6	38	.587	.000
Pair 13	sq4 & sq5	38	.733	.000
Pair 14	sq4 & sq6	38	.748	.000
Pair 15	sq5 & sq6	38	.698	.000

Paired Samples Test

		Paired Differences				
					95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	Sq1 - sq2	-3.342	2.539	.412	-4.177	-2.508
Pair 2	Sq1 - sq3	-3.632	3.475	.564	-4.774	-2.489
Pair 3	Sq1 - sq4	-3.842	3.373	.547	-4.951	-2.733
Pair 4	Sq1 - sq5	-3.474	3.203	.520	-4.526	-2.421
Pair 5	Sq1 - sq6	-3.395	3.413	.554	-4.517	-2.273
Pair 6	sq2 - sq3	-.289	2.949	.478	-1.259	.680
Pair 7	sq2 - sq4	-.500	3.020	.490	-1.493	.493
Pair 8	sq2 - sq5	-.132	2.849	.462	-1.068	.805
Pair 9	sq2 - sq6	-.053	3.271	.531	-1.128	1.023
Pair 10	sq3 - sq4	-.211	1.961	.318	-.855	.434
Pair 11	sq3 - sq5	.158	2.086	.338	-.528	.844
Pair 12	sq3 - sq6	.237	2.726	.442	-.659	1.133
Pair 13	sq4 - sq5	.368	2.059	.334	-.308	1.045
Pair 14	sq4 - sq6	.447	2.063	.335	-.231	1.125
Pair 15	sq5 - sq6	.079	2.058	.334	-.598	.756

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	Sq1 - sq2	-8.114	37	.000
Pair 2	Sq1 - sq3	-6.442	37	.000
Pair 3	Sq1 - sq4	-7.021	37	.000
Pair 4	Sq1 - sq5	-6.686	37	.000
Pair 5	Sq1 - sq6	-6.131	37	.000
Pair 6	sq2 - sq3	-.605	37	.549
Pair 7	sq2 - sq4	-1.021	37	.314
Pair 8	sq2 - sq5	-.285	37	.777
Pair 9	sq2 - sq6	-.099	37	.922
Pair 10	sq3 - sq4	-.662	37	.512
Pair 11	sq3 - sq5	.467	37	.644
Pair 12	sq3 - sq6	.536	37	.595
Pair 13	sq4 - sq5	1.103	37	.277
Pair 14	sq4 - sq6	1.337	37	.189
Pair 15	sq5 - sq6	.236	37	.814

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	vpsq1	16.5532	38	15.16980	2.46087
	vpsq2	19.9746	38	11.98463	1.94416
Pair 2	vpsq1	16.5532	38	15.16980	2.46087
	vpsq3	25.5370	38	17.01163	2.75965
Pair 3	vpsq1	16.5532	38	15.16980	2.46087
	vpsq4	25.6750	38	14.27307	2.31540
Pair 4	vpsq1	16.5532	38	15.16980	2.46087
	vpsq5	25.7469	38	11.14744	1.80835
Pair 5	vpsq1	16.5532	38	15.16980	2.46087
	vpsq6	22.4676	38	11.02509	1.78851
Pair 6	vpsq2	19.9746	38	11.98463	1.94416
	vpsq3	25.5370	38	17.01163	2.75965
Pair 7	vpsq2	19.9746	38	11.98463	1.94416
	vpsq4	25.6750	38	14.27307	2.31540
Pair 8	vpsq2	19.9746	38	11.98463	1.94416
	vpsq5	25.7469	38	11.14744	1.80835
Pair 9	vpsq2	19.9746	38	11.98463	1.94416
	vpsq6	22.4676	38	11.02509	1.78851
Pair 10	vpsq3	25.5370	38	17.01163	2.75965
	vpsq4	25.6750	38	14.27307	2.31540
Pair 11	vpsq3	25.5370	38	17.01163	2.75965
	vpsq5	25.7469	38	11.14744	1.80835
Pair 12	vpsq3	25.5370	38	17.01163	2.75965
	vpsq6	22.4676	38	11.02509	1.78851
Pair 13	vpsq4	25.6750	38	14.27307	2.31540
	vpsq5	25.7469	38	11.14744	1.80835
Pair 14	vpsq4	25.6750	38	14.27307	2.31540
	vpsq6	22.4676	38	11.02509	1.78851
Pair 15	vpsq5	25.7469	38	11.14744	1.80835
	vpsq6	22.4676	38	11.02509	1.78851

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	vpsq1 & vpsq2	38	.163	.328
Pair 2	vpsq1 & vpsq3	38	.288	.079
Pair 3	vpsq1 & vpsq4	38	.311	.057
Pair 4	vpsq1 & vpsq5	38	.296	.071
Pair 5	vpsq1 & vpsq6	38	.226	.173
Pair 6	vpsq2 & vpsq3	38	.555	.000
Pair 7	vpsq2 & vpsq4	38	.331	.042
Pair 8	vpsq2 & vpsq5	38	.639	.000
Pair 9	vpsq2 & vpsq6	38	.406	.011
Pair 10	vpsq3 & vpsq4	38	.767	.000
Pair 11	vpsq3 & vpsq5	38	.707	.000
Pair 12	vpsq3 & vpsq6	38	.478	.002
Pair 13	vpsq4 & vpsq5	38	.511	.001
Pair 14	vpsq4 & vpsq6	38	.350	.031
Pair 15	vpsq5 & vpsq6	38	.660	.000

Paired Samples Test

		Paired Differences				
					95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	vpsq1 - vpsq2	-3.42144	17.73369	2.87678	-9.25036	2.40747
Pair 2	vpsq1 - vpsq3	-8.98387	19.25200	3.12309	-15.31184	-2.65589
Pair 3	vpsq1 - vpsq4	-9.12181	17.29216	2.80516	-14.80560	-3.43802
Pair 4	vpsq1 - vpsq5	-9.19375	15.94894	2.58726	-14.43603	-3.95146
Pair 5	vpsq1 - vpsq6	-5.91445	16.61805	2.69580	-11.37667	-.45224
Pair 6	vpsq2 - vpsq3	-5.56242	14.38461	2.33349	-10.29053	-.83432
Pair 7	vpsq2 - vpsq4	-5.70037	15.29998	2.48198	-10.72935	-.67139
Pair 8	vpsq2 - vpsq5	-5.77230	9.85741	1.59908	-9.01235	-2.53225
Pair 9	vpsq2 - vpsq6	-2.49301	12.56656	2.03857	-6.62354	1.63752
Pair 10	vpsq3 - vpsq4	-.13795	10.99255	1.78323	-3.75111	3.47522
Pair 11	vpsq3 - vpsq5	-.20988	12.07074	1.95813	-4.17743	3.75767
Pair 12	vpsq3 - vpsq6	3.06941	15.22389	2.46964	-1.93456	8.07338
Pair 13	vpsq4 - vpsq5	-.07193	12.85596	2.08551	-4.29758	4.15371
Pair 14	vpsq4 - vpsq6	3.20736	14.66254	2.37858	-1.61210	8.02682
Pair 15	vpsq5 - vpsq6	3.27929	9.14139	1.48293	.27459	6.28399

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	vpsq1 - vpsq2	-1.189	37	.242
Pair 2	vpsq1 - vpsq3	-2.877	37	.007
Pair 3	vpsq1 - vpsq4	-3.252	37	.002
Pair 4	vpsq1 - vpsq5	-3.553	37	.001
Pair 5	vpsq1 - vpsq6	-2.194	37	.035
Pair 6	vpsq2 - vpsq3	-2.384	37	.022
Pair 7	vpsq2 - vpsq4	-2.297	37	.027
Pair 8	vpsq2 - vpsq5	-3.610	37	.001
Pair 9	vpsq2 - vpsq6	-1.223	37	.229
Pair 10	vpsq3 - vpsq4	-.077	37	.939
Pair 11	vpsq3 - vpsq5	-.107	37	.915
Pair 12	vpsq3 - vpsq6	1.243	37	.222
Pair 13	vpsq4 - vpsq5	-.034	37	.973
Pair 14	vpsq4 - vpsq6	1.348	37	.186
Pair 15	vpsq5 - vpsq6	2.211	37	.033

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	TBrk1	3.1842	38	1.55712	.25260
	TBrk2	4.7895	38	1.67909	.27238
Pair 2	TBrk1	3.1842	38	1.55712	.25260
	TBrk3	5.1316	38	1.63031	.26447
Pair 3	TBrk1	3.1842	38	1.55712	.25260
	TBrk4	4.2632	38	1.75043	.28396
Pair 4	TBrk1	3.1842	38	1.55712	.25260
	TBrk5	5.3947	38	1.76359	.28609
Pair 5	TBrk1	3.1842	38	1.55712	.25260
	TBrk6	5.1316	38	1.90548	.30911
Pair 6	TBrk2	4.7895	38	1.67909	.27238
	TBrk3	5.1316	38	1.63031	.26447
Pair 7	TBrk2	4.7895	38	1.67909	.27238
	TBrk4	4.2632	38	1.75043	.28396
Pair 8	TBrk2	4.7895	38	1.67909	.27238
	TBrk5	5.3947	38	1.76359	.28609
Pair 9	TBrk2	4.7895	38	1.67909	.27238
	TBrk6	5.1316	38	1.90548	.30911
Pair 10	TBrk3	5.1316	38	1.63031	.26447
	TBrk4	4.2632	38	1.75043	.28396
Pair 11	TBrk3	5.1316	38	1.63031	.26447
	TBrk5	5.3947	38	1.76359	.28609
Pair 12	TBrk3	5.1316	38	1.63031	.26447
	TBrk6	5.1316	38	1.90548	.30911
Pair 13	TBrk4	4.2632	38	1.75043	.28396
	TBrk5	5.3947	38	1.76359	.28609
Pair 14	TBrk4	4.2632	38	1.75043	.28396
	TBrk6	5.1316	38	1.90548	.30911
Pair 15	TBrk5	5.3947	38	1.76359	.28609
	TBrk6	5.1316	38	1.90548	.30911

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	TBrk1 & TBrk2	38	.666	.000
Pair 2	TBrk1 & TBrk3	38	.395	.014
Pair 3	TBrk1 & TBrk4	38	.299	.068
Pair 4	TBrk1 & TBrk5	38	.327	.045
Pair 5	TBrk1 & TBrk6	38	.283	.085
Pair 6	TBrk2 & TBrk3	38	.573	.000
Pair 7	TBrk2 & TBrk4	38	.166	.318
Pair 8	TBrk2 & TBrk5	38	.275	.094
Pair 9	TBrk2 & TBrk6	38	.161	.334
Pair 10	TBrk3 & TBrk4	38	.433	.007
Pair 11	TBrk3 & TBrk5	38	.583	.000
Pair 12	TBrk3 & TBrk6	38	.516	.001
Pair 13	TBrk4 & TBrk5	38	.596	.000
Pair 14	TBrk4 & TBrk6	38	.557	.000
Pair 15	TBrk5 & TBrk6	38	.547	.000

Paired Samples Test

		Paired Differences				
					95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	TBrk1 - TBrk2	-1.60526	1.32623	.21514	-2.04118	-1.16934
Pair 2	TBrk1 - TBrk3	-1.94737	1.75449	.28462	-2.52406	-1.37068
Pair 3	TBrk1 - TBrk4	-1.07895	1.96430	.31865	-1.72460	-.43330
Pair 4	TBrk1 - TBrk5	-2.21053	1.93346	.31365	-2.84604	-1.57501
Pair 5	TBrk1 - TBrk6	-1.94737	2.09178	.33933	-2.63492	-1.25982
Pair 6	TBrk2 - TBrk3	-.34211	1.52946	.24811	-.84483	.16062
Pair 7	TBrk2 - TBrk4	.52632	2.21465	.35926	-.20162	1.25425
Pair 8	TBrk2 - TBrk5	-.60526	2.07351	.33637	-1.28681	.07628
Pair 9	TBrk2 - TBrk6	-.34211	2.32816	.37768	-1.10735	.42314
Pair 10	TBrk3 - TBrk4	.86842	1.80347	.29256	.27564	1.46121
Pair 11	TBrk3 - TBrk5	-.26316	1.55414	.25212	-.77399	.24768
Pair 12	TBrk3 - TBrk6	.00000	1.75530	.28475	-.57695	.57695
Pair 13	TBrk4 - TBrk5	-1.13158	1.57979	.25628	-1.65084	-.61232
Pair 14	TBrk4 - TBrk6	-.86842	1.72691	.28014	-1.43604	-.30080
Pair 15	TBrk5 - TBrk6	.26316	1.75043	.28396	-.31219	.83851

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	TBrk1 - TBrk2	-7.461	37	.000
Pair 2	TBrk1 - TBrk3	-6.842	37	.000
Pair 3	TBrk1 - TBrk4	-3.386	37	.002
Pair 4	TBrk1 - TBrk5	-7.048	37	.000
Pair 5	TBrk1 - TBrk6	-5.739	37	.000
Pair 6	TBrk2 - TBrk3	-1.379	37	.176
Pair 7	TBrk2 - TBrk4	1.465	37	.151
Pair 8	TBrk2 - TBrk5	-1.799	37	.080
Pair 9	TBrk2 - TBrk6	-.906	37	.371
Pair 10	TBrk3 - TBrk4	2.968	37	.005
Pair 11	TBrk3 - TBrk5	-1.044	37	.303
Pair 12	TBrk3 - TBrk6	.000	37	1.000
Pair 13	TBrk4 - TBrk5	-4.415	37	.000
Pair 14	TBrk4 - TBrk6	-3.100	37	.004
Pair 15	TBrk5 - TBrk6	.927	37	.360

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	FBrk1	1.9474	38	1.03838	.16845
	FBrk2	1.8158	38	1.06175	.17224
Pair 2	FBrk1	1.9474	38	1.03838	.16845
	FBrk3	1.7895	38	.99071	.16071
Pair 3	FBrk1	1.9474	38	1.03838	.16845
	FBrk4	1.7895	38	.99071	.16071
Pair 4	FBrk1	1.9474	38	1.03838	.16845
	FBrk5	1.7105	38	.86705	.14065
Pair 5	FBrk1	1.9474	38	1.03838	.16845
	FBrk6	1.8947	38	1.06007	.17197
Pair 6	FBrk2	1.8158	38	1.06175	.17224
	FBrk3	1.7895	38	.99071	.16071
Pair 7	FBrk2	1.8158	38	1.06175	.17224
	FBrk4	1.7895	38	.99071	.16071
Pair 8	FBrk2	1.8158	38	1.06175	.17224
	FBrk5	1.7105	38	.86705	.14065
Pair 9	FBrk2	1.8158	38	1.06175	.17224
	FBrk6	1.8947	38	1.06007	.17197
Pair 10	FBrk3	1.7895	38	.99071	.16071
	FBrk4	1.7895	38	.99071	.16071
Pair 11	FBrk3	1.7895	38	.99071	.16071
	FBrk5	1.7105	38	.86705	.14065
Pair 12	FBrk3	1.7895	38	.99071	.16071
	FBrk6	1.8947	38	1.06007	.17197
Pair 13	FBrk4	1.7895	38	.99071	.16071
	FBrk5	1.7105	38	.86705	.14065
Pair 14	FBrk4	1.7895	38	.99071	.16071
	FBrk6	1.8947	38	1.06007	.17197
Pair 15	FBrk5	1.7105	38	.86705	.14065
	FBrk6	1.8947	38	1.06007	.17197

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	FBrk1 & FBrk2	38	.824	.000
Pair 2	FBrk1 & FBrk3	38	.646	.000
Pair 3	FBrk1 & FBrk4	38	.619	.000
Pair 4	FBrk1 & FBrk5	38	.673	.000
Pair 5	FBrk1 & FBrk6	38	.461	.004
Pair 6	FBrk2 & FBrk3	38	.707	.000
Pair 7	FBrk2 & FBrk4	38	.579	.000
Pair 8	FBrk2 & FBrk5	38	.586	.000
Pair 9	FBrk2 & FBrk6	38	.559	.000
Pair 10	FBrk3 & FBrk4	38	.752	.000
Pair 11	FBrk3 & FBrk5	38	.588	.000
Pair 12	FBrk3 & FBrk6	38	.647	.000
Pair 13	FBrk4 & FBrk5	38	.777	.000
Pair 14	FBrk4 & FBrk6	38	.853	.000
Pair 15	FBrk5 & FBrk6	38	.760	.000

Paired Samples Test

		Paired Differences				
					95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	FBrk1 - FBrk2	.13158	.62259	.10100	-.07306	.33622
Pair 2	FBrk1 - FBrk3	.15789	.85507	.13871	-.12316	.43895
Pair 3	FBrk1 - FBrk4	.15789	.88612	.14375	-.13337	.44915
Pair 4	FBrk1 - FBrk5	.23684	.78617	.12753	-.02157	.49525
Pair 5	FBrk1 - FBrk6	.05263	1.08919	.17669	-.30538	.41064
Pair 6	FBrk2 - FBrk3	.02632	.78798	.12783	-.23269	.28532
Pair 7	FBrk2 - FBrk4	.02632	.94402	.15314	-.28398	.33661
Pair 8	FBrk2 - FBrk5	.10526	.89411	.14504	-.18862	.39915
Pair 9	FBrk2 - FBrk6	-.07895	.99679	.16170	-.40659	.24869
Pair 10	FBrk3 - FBrk4	.00000	.69749	.11315	-.22926	.22926
Pair 11	FBrk3 - FBrk5	.07895	.85049	.13797	-.20060	.35850
Pair 12	FBrk3 - FBrk6	-.10526	.86335	.14005	-.38904	.17851
Pair 13	FBrk4 - FBrk5	.07895	.63167	.10247	-.12868	.28657
Pair 14	FBrk4 - FBrk6	-.10526	.55941	.09075	-.28914	.07861
Pair 15	FBrk5 - FBrk6	-.18421	.69185	.11223	-.41162	.04320

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	FBrk1 - FBrk2	1.303	37	.201
Pair 2	FBrk1 - FBrk3	1.138	37	.262
Pair 3	FBrk1 - FBrk4	1.098	37	.279
Pair 4	FBrk1 - FBrk5	1.857	37	.071
Pair 5	FBrk1 - FBrk6	.298	37	.767
Pair 6	FBrk2 - FBrk3	.206	37	.838
Pair 7	FBrk2 - FBrk4	.172	37	.864
Pair 8	FBrk2 - FBrk5	.726	37	.473
Pair 9	FBrk2 - FBrk6	-.488	37	.628
Pair 10	FBrk3 - FBrk4	.000	37	1.000
Pair 11	FBrk3 - FBrk5	.572	37	.571
Pair 12	FBrk3 - FBrk6	-.752	37	.457
Pair 13	FBrk4 - FBrk5	.770	37	.446
Pair 14	FBrk4 - FBrk6	-1.160	37	.254
Pair 15	FBrk5 - FBrk6	-1.641	37	.109

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	preusg	1.01711	38	.008877	.001440
	postusg	1.01995	38	.007476	.001213

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	preusg & postusg	38	.552	.000

Paired Samples Test

		Paired Differences				
					95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	preusg - postusg	-.002842	.007838	.001271	-.005418	-.000266

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	preusg - postusg	-2.235	37	.032

APPENDIX E: RECOMMENDATIONS

Improvements for methodology

• Use nude weight to improve accuracy of hydration calculations.

• Increase the number of participants to improve power calculations.

• Standardize the number of days between each condition.

• Change when perceptual scales are given. First during weigh in, then after the dynamic warm-up/exercise station, as well as after each fluid break, before the start of the next exercise station. By obtaining values before and after each fluid break, we can use the difference of scores to better assess the influence of fluid administration on perception of thirst and fullness.

Progression in the research field

• Effect of fluid administration on fluid consumption and hydration status with free access to fluids.

• Effect of fluid administration on fluid consumption and hydration status during high school and collegiate football practices.

• Effect of fluid administration on fluid consumption and hydration status during competitive play.

• Reported alliesthesia of varying water bottle temperatures.

• Reported alliesthesia of varying water bottle temperatures in several environmental conditions.

• Qualitative questionnaire based on SA and EFA methods evaluating preference/comfort level, past experiences, thoughts on accuracy/efficiency.

• Efficiency of varying fluid administration methods (SA vs. EFA).