The Effect of Thirst and Pharyngeal Stimulation on Exercise Performance

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“The Effect of Thirst and Pharyngeal Stimulation on Exercise Performance”

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2016
College of Education and Health Professions
The University of Arkansas

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Dr. Matthew S. Ganio

An Honors Thesis submitted in cohorts with fulfillment of the requirements for Honors Studies in Kinesiology
ABSTRACT:

Purpose: The purpose of this research was to determine if activating the oral-pharyngeal receptors through the act of swallowing plays a role in enhancing exercise performance. It was hypothesized that stimulation of the pharyngeal receptors through the act of swallowing (D trial) increases exercise performance when compared to infusing the same amount of liquid via a nasogastric tube (I trial).

Methods: Five trained male cyclists (31 ± 5 years; 74.7 ± 4 kg; 57 ± 3 mL/kg/min) performed two trials in a counterbalanced fashion, each consisting of 120 minutes cycling in an environment at 35°C and 30% RH at 55% VO2max followed by a 5k-performance test. Participants completed these trials by drinking 25mL of water every 5 minutes or by having 25mL of water infused every 5 minutes through a nasogastric tube. Blood and urine samples were collected before and after the trials. Heart rate, skin temperature, and core temperature were recorded systematically throughout the protocol, and the participants’ perception of thirst, mouth dryness, and stomach fullness were also recorded via a visual analog scale.

Results: All five cyclists completed the performance test following the D trial, but two cyclists failed to complete the performance test following the I trial due to fatigue and lightheadedness. The time to completion for the D and I trials were 13.35 ± 0.54 verses 13.18 ± 0.86 min respectively. Core body temperature (Tc) showed a 0.37°C increase following the 2 hour cycle during the I trial but a 0.30°C decrease following the 5k. Heart rate following the Infusion trial (I) averaged 187 bpm when compared with the drinking trial (D) of 189 bpm.

Conclusions: Stimulating the receptors by swallowing might play a role in enhancing exercise performance, but more trials will need to be completed in order to evaluate this question.

INTRODUCTION:

Fluid replacement during exercise is crucial for competitive, endurance athletes, where shaving a minute or a couple seconds off their time could mean winning their competition, but it’s more important than that. Maintaining appropriate fluid balance within the body while performing allows for proper body functioning and overall health.

Dehydration by as little as 2% of body weight during exercise has been proven to cause fatigue and decreased performance (3,4, 6). Reasons for this include a fall in plasma volume, which decreases overall blood volume and makes
the blood more viscous (6). All of these factors contribute to reduced cardiac output and limit blood delivery to the active muscles making it near impossible to sustain exercise at the same level because the heart then has to pump harder and faster in order to deliver the appropriate amount of blood and oxygen to the active muscles making the athlete susceptible to more dangerous health risks (3). Studies have shown that getting the appropriate amount of fluid replacement decreases these effects (1,2). One of the many feedback control mechanisms in the body for fluid balance is thirst. However, at what point in a person’s hydration status does their perception of thirst become imperative to performance/ability. Thirst is usually activated when body water deficit exceeds 1% of body mass, even ingesting a small amount of water during exercise has been proven to delay fatigue (5,2,7). This has led researchers to begin investigating the role pharyngeal receptors play in exercise performance. It is known that oral-pharyngeal receptors modulate thirst, and recent data suggests that mouth rinsing or just drinking a small amount of water could positively influence athletic performance in dehydrated subjects (5). One study has shown that there is a clear trend toward increased performance when fluid passes through the mouth and down the typical pathway when compared to intravenous replacement (8). A reason for this could be due to the modulatory effects the oral pharyngeal receptors, but their physiological implications are still not entirely clear.

From the data mentioned above, we can conclude that both hydration status and thirst play a role in exercise performance. Receptor stimulation and the act of swallowing might be enough for a short burst in performance, but is it enough to sustain performance over a longer period of time? The idea behind this project
stemmed from curiosity in the actual role of pharyngeal receptors and human perception of thirst, as well as their effect on exercise performance. Could we bypass the receptors and still provide adequate fluid intake to maintain performance? Does perceived thirst play a role in the hydration status of a person? The purpose of this research study is to examine the effect of pharyngeal receptors on cycling performance in a warm, dry climate using various methods of fluid ingestion. By inserting a nasogastric (NG) tube, we are able to bypass the receptors and infuse the same amount of liquid in order to maintain identical hydration states. This allows for true testing of receptor stimulation on performance.

**HYPOTHESIS:**

We hypothesized that actually drinking the water, will contribute to better exercise performance; whereas, just injecting fluid into their stomach will maintain their hydration status, but decrease exercise performance due to lack of receptor stimulation.

**METHODS:**

**Subjects:**

Five male cyclists participated in this study. Inclusionary criteria consisted of a VO2peak ≥ 55ml/kg/min or a CAT 3 USA cycling license and an age between eighteen and fifty years old. Characteristics for this group included age: 31 ± 5 years, body mass: 75 ± 4 kg, percent body fat: 15.2 ± 3%, and VO2peak: 57.5 ± 3 mL/kg/min. Participants were also briefed on and asked to attempt insertion of a nasogastric tube before progressing through the protocol.
**Familiarization Visit:**

At least 24 hours after the informational visit, a familiarization was done to introduce the participant to the protocol and make necessary adjustments to the cycle ergometer. During this visit, the participants exercised on an electronically braked cycle ergometer for 2 hours at 55% of his VO2 Max in a temperature controlled climate of 35 °C and 30% Relative Humidity. Once the subjects completed the information and familiarization visits, they were deemed ready for the experimental trials.

**Experimental Trials:**

For the purpose of this thesis, the participants performed 2 separate, counterbalanced trials: one in which the cyclist drank 25mL of water every 5 minutes and one in which every 5 minutes the same amount of water was inserted via a nasogastric tube to avoid receptor stimulation. The cyclists were to ride on a cycle ergometer for 2 hours in a warm, relatively dry environment (35°C, 30% RH) at 55% their VO2 Max with an industrial fan in front of them running around 4m/second. This was done to ensure moderate intensity performance and induce full evaporation of sweat.

Performance in each trial was separated by at least a week to warrant adequate rehydration. Twenty-four hours before the trail, the subjects were asked to refrain from alcohol, caffeine, and non-prescription drugs. They were also asked to drink an additional 4 cups (32oz.) of water the night before and 2 cups (16oz.) of water 2-3 hours before the trial. When the subject came in, an initial urine sample was taken to ensure euhydration. While in the private bathroom, he was also asked...
to step on the scale for a pre-exercise body weight and to insert the rectal thermometer 10 cm past the anal sphincter for the most accurate core body temperature reading during the trial. Then, when the subject came out, a trained researcher assisted with NG-tube insertion (premeasured from the tip of the nose, behind the ear, to the tip of the sternum) and the urine USG was tested to confirm proper hydration. The subject was then asked to strap on a heart rate monitoring device and four skin temperature thermocouples to the right side of the body (the calf, upper thigh, arm, and chest). All of this is done to maintain accurate recordings throughout the trial.

Following instrumentation, the subject mounted the cycle ergometer and a small blood sample was obtained from his antecubital vein. For the next 120 minutes, the subject cycled at 55% his VO2 max. During this time, every 10 minutes the ambient temperature and the relative humidity of the room were recorded in order to maintain the conditions. The subject also answered the following perceptual questions “How thirsty do you feel now?”, “How dry does your mouth feel now?”, and “How full does your stomach feel now?”. This was done using a visual analog scale line of 15cm, and asking the participant to draw a perpendicular mark on the line where he felt it applied. Every 5 minutes, his heart rate and core temperature were recorded, and he was given 25mL of water either orally or through an NG tube. VO2 and RER were also measured every 20 minutes to make sure the subject was maintaining moderate level exercise. Directly following the 2-hour trial, another blood sample was taken and a 5K timed trial was done. Once the 5K trial was complete, one last blood sample was taken, and the subject was able to
dismount the bicycle. At this stage, the participant was allowed to go to the restroom to gather another urine sample and body temperature recording. The NG-tube and anal thermometer were removed, and the subject was free to leave. Again, this was done a total of 2 separate times, one week apart.

Trial A. The subject drank 25mL of water every 5 minutes.

Trial B. The subject had 25mL of water infused through a nasogastric tube every 5 minutes.

This allowed us to monitor and maintain equal hydration states between the two trials, in order to further understand the role of the oral-pharyngeal receptors in athletic performance. The trials were done in a counterbalance fashion. Below is a visual chart with the different dependent variables that we measured/recorded:

Figure 1: Experimental Protocol
RESULTS:

Table 1: Mean body weight before (Pre) and after (Post), body weight (BW) loss, % dehydration, sweat loss, and sweat rate values for the 120-minute cycling session. *Values are expressed as a mean ± Standard Error (SE).

<table>
<thead>
<tr>
<th></th>
<th>Drink</th>
<th>Infusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre BW (kg)</td>
<td>75.1 ± 3.2</td>
<td>74.6 ± 3.4</td>
</tr>
<tr>
<td>Post BW (kg)</td>
<td>73.4 ± 7.1</td>
<td>72.7 ± 3.4</td>
</tr>
<tr>
<td>BW Loss (kg)</td>
<td>1.7 ± 0.14</td>
<td>2.0 ± 0.09</td>
</tr>
<tr>
<td>Percent Dehydration (%)</td>
<td>2.2 ± 0.19</td>
<td>2.7 ± 0.13</td>
</tr>
<tr>
<td>Sweat Loss (L)</td>
<td>2.3 ± 0.14</td>
<td>2.5 ± 0.08</td>
</tr>
<tr>
<td>Sweat Rate (L/hr)</td>
<td>1.1 ± 0.07</td>
<td>1.3 ± 0.04</td>
</tr>
</tbody>
</table>

Table 2: Mean body weight before (Pre) and after (Post), sweat loss, sweat rate, percent dehydration, completion time, and power values were calculated following the 5K timed trial performance session. *Values are expressed as a mean ± Standard Error (SE).

<table>
<thead>
<tr>
<th></th>
<th>Drink</th>
<th>Infuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre BW (kg)</td>
<td>71 ± 0.3</td>
<td>70.4 ± 0.2</td>
</tr>
<tr>
<td>Post BW (kg)</td>
<td>70.6 ± 0.45</td>
<td>70.1 ± 0.1</td>
</tr>
<tr>
<td>Sweat Loss (L)</td>
<td>0.45 ± 0.08</td>
<td>0.3 ± 0.04</td>
</tr>
<tr>
<td>% Dehydration (%)</td>
<td>0.6 ± 0.2</td>
<td>0.4 ± 0.1</td>
</tr>
<tr>
<td>Sweat Rate (L/hr)</td>
<td>1.64 ± 0.5</td>
<td>1.54 ± 0.3</td>
</tr>
<tr>
<td>Completion Time (min)</td>
<td>13.4 ± 0.5</td>
<td>13.2 ± 0.9</td>
</tr>
<tr>
<td>Power (Watts)</td>
<td>281 ± 15</td>
<td>286 ± 22</td>
</tr>
</tbody>
</table>
**Figure 2**: Participant HR at various time points throughout the 120 minute cycle period. 
*Values are expressed as a mean ± Standard Error (SE).*

**Figure 3**: Heart Rate values over the course of the 120 min cycle and the 5k timed performance trial.
**Figure 4:** Skin Temperature for the Drink and the Infusion trials during the 120minute cycling session. *Values are expressed as a mean ± Standard Error (SE).

**Figure 5:** Mean Skin Temperature for the Drink and the Infusion trials during the 5k timed trial. *Values are expressed as a mean ± Standard Error (SE).
Figure 6: Rectal Temperature for the Drink and the Infusion trials during the 120 minute cycling session. *Values are expressed as a mean ± Standard Error (SE).

Figure 7: Rectal Temperature for the Drink and the Infusion trials during the 5k timed trial. *Values are expressed as a mean ± Standard Error (SE).
**Figure 8**: Urine Osmolality (UOsm) values before (Pre), during transition from 120min cycle to 5k (Between), and after the trial is complete (Post). *Values are expressed as a mean ± Standard Error (SE).

**Figure 9**: Plasma Osmolality (POsm) values Pre 120min cycle, Between the 120min cycle and timed trial, and Post timed trial. *Values are expressed as a mean ± Standard Error (SE).
**Figure 10:** Shows the comparison of the sweat loss, sweat rate, body weight loss, and percent dehydration for the Drink and Infusion trials during the 120min. cycle *Values are expressed as a mean ± Standard Error (SE)*

**Figure 11:** Comparison of sweat loss, sweat rate, body weight loss, and percent dehydration for the Drink and Infusion 5k-timed trials. *Values are expressed as a mean ± Standard Error (SE).*
Table 3: Values for the Visual Analog Scale before (Pre) and after (Post) 5k timed trial performance, where Thirst (T), Mouth Dryness (MD), and Stomach Fullness (SF) were measured based off a 15cm scale. *Values are expressed as a mean ± Standard Error (SE).  

<table>
<thead>
<tr>
<th>VAS (cm)</th>
<th>Drink</th>
<th>Infuse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre 5k</td>
<td>Post 5k</td>
</tr>
<tr>
<td>T</td>
<td>3.5 ± 1.4</td>
<td>5.5 ± 1.9</td>
</tr>
<tr>
<td>MD</td>
<td>2.6 ± 0.8</td>
<td>5.4 ± 2.0</td>
</tr>
<tr>
<td>SF</td>
<td>3.8 ± 1.0</td>
<td>6.0 ± 1.6</td>
</tr>
</tbody>
</table>

Table 1 shows that body mass lost was greater in the 120minute I trial (2.0 ± 0.09 kg) when compared to the D trial (1.7 ± 0.14 kg). The I trial also led to a greater sweat loss deficit with the difference between the I and D trial being 0.27 kg in the 120 minute cycle. This trend is confirmed again by the sweat rate being greater in the I trial of the 120minute cycle. In contrast, during the 5k performance (Figure 11), the D trial showed almost equal sweat loss, a higher sweat rate, a higher BW loss, and greater percent dehydration in comparison of the I trial. According to Table 2, the infusion trial finished an average 0.17minutes before the drinking trial. As a result of this experiment, a lower heart rate was maintained during the drinking trial in the 120minute cycle (Fig. 2), but the average heart rate over the entire trial (Fig. 3) shows no real trend in the data. Based off Figures 4 and 5, Tsk did not show much change between the data sets. The infused Tsk did maintain a higher average temperature during the 5k by a 0.26 °C difference, but this difference mainly came from the start of the 5k and the values between the D and I trials became closer over the course of the 5k. Core Temperature (Tc) displayed higher in the I trial at the end of the 2 Hour Cycle (Fig. 6) but was lower in the I trial at the end.
of the 5k timed performance test (Fig. 7). Based off Figure 9, plasma osmolality shows a steady increase in both trials. However, urine osmolality (Figure 8) showed a fairly large discrepancy between the D and I trials. Urine osmolality decreased in the drinking trial, but increased in the infusion trial. Percent dehydration and body weight loss appeared greater during the 120minute infusion trial (Fig. 10); whereas in the 5k performance (Fig.11), the drinking trial showed a larger average sweat rate, body weight loss and percent dehydration. Table 3 shows a trend that in the I trial, people start and end the 5k thirstier, with more mouth dryness and a more full stomach than in the D trial.

**DISCUSSION:**

In the present study, we examined the effect of oral-pharyngeal receptor stimulation on exercise performance. This was done by comparing the physical performance, heart rate, body temperature, sweat rate, plasma osmolality, urine osmolality, and self-perception of thirst, mouth dryness, and stomach fullness of subjects who performed one trial via infusion of water to bypass the receptors and one via the normal digestive pathway. To the best of our knowledge, this was the first study to investigate the role of the receptors, while attempting to maintain identical hydration states in each trial through NG tube infusion. It was found that drinking the water contributed to an increase in plasma osmolality but a decrease in urine osmolality; whereas in the infusion trial there was an increase in both plasma and urine osmolality. The fact that they felt more full during the infusion trial compared to drinking the same amount (Table 3) could be due to the fact that water
is absorbed as it moves down the digestive tract when in the infusion trial water is pumped directly into their stomach. In addition, the infusion trial showed a greater body weight loss due to sweat compared to the drinking trial during the 120-minute cycle. The greater sweat loss contributed to a greater percent dehydration. Contrary to the 5k timed trial data, where a higher sweat rate was found in the D trial. This data is consistent with data collected previously--mentioning that activation of the receptors reduces osmotic inhibitory input to the brain centers, which induces more sweating (9). Other studies have shown oral-pharyngeal receptors as modulators of thirst, and data from a 2012 study suggests that mouth rinsing or just drinking a small amount of water could positively influence athletic performance in dehydrated subjects (5). Another study also noted a visible increase in exercise performance when water was ingested when compared to intravenous replacement (8). Two out of the five subjects in our experiment could not even start the 5k timed trial after the infusion, which could be linked to decreased exercise performance. However, during the 5k-timed trial, no real change presented itself with respect to exercise performance. The D trial finished at 13.4 ± 0.5, where the I trial finished at 13.2 ± 0.86 minutes.

We acknowledge that possible limitations to our study exist. With only 5 subjects, we couldn’t really provide any values of true significance. This is a time consuming study and needs to be completed in a consistent fashion with strict diet in order to accurately evaluate the results. Even so, we ended up having two participants fail to complete the 5k-timed trial following the 120minute infusion trial just by pure exhaustion/thirst. This also limited our data for the infusion 5k
results and could skew the data. In order to produce more accurate results, infusing or drinking to sweat rate (based on the individual) might be advantageous to those who work at a higher sweat rates.

**CONCLUSION:**

Fluid regulation is essential to homeostasis. If water levels fall below normal limits, many bodily functions fail to proceed at their normal rates, but could the same be said for oral pharyngeal receptor stimulation? The purpose of this study was to determine if the act of swallowing/ stimulating the receptors does enhance exercise when hydration state is not a factor. Due to the lack of participants at this point, no real trends have been found other than the failure of two out of the five subjects to even start the 5k-timed trial after the 2 hour cycle at 55% their VO2 Max due to light headedness and/or a light headache. Further research should be continued to investigate the true implications of oral pharyngeal receptor stimulation on exercise performance.

**ACKNOWLEDGEMENTS:**

The authors would like to thank all of the subjects for their time and effort during this study and for making this project possible. The authors would also like to thank the students and faculty of the Human Performance Lab for contributing their time and energies into making sure everything ran smoothly and efficiently.
RESOURCES:


Appendix A:

The Consent Form

Effect of Mode of Fluid Ingestion on Cycling Performance

Principal Researcher: J.D. Adams Faculty Advisor: Dr. Stavros Kavouras

INVITATION TO PARTICIPATE

You are invited to participate in a research study evaluating the effects of different modes of fluid ingestion on cycling performance in the heat. You are being asked to participate in this study because you are a healthy male between the ages of 18 and 45.

WHAT YOU SHOULD KNOW ABOUT THE RESEARCH STUDY

Who is the Principal Researcher?

J.D. Adams; jxa014@uark.edu

Who is the Faculty Advisor?

Dr. Stavros Kavouras; kavouras@uark.edu

What is the purpose of this research study?

The purpose of this study is to examine thermoregulatory, cardiovascular, and perceptual responses to different modes of fluid ingesting while cycling in the heat.

Who will participate in this study?

There will be no more than 28 males participating in this study. The individuals will be between 18 and 50 years of age. They will be a mix of University of Arkansas students and non-students. Females will be excluded from the study as endogenous hormones can cause alterations in fluid balance and thermoregulation. This in turn would only allow the researchers to recruit the females for a trial once a month. This study is trying to elucidate the effects of hydration and thermoregulation. By recruiting females once a month,
researchers will not be able to control for the aspect of heat acclimatization, which will inhibit the researcher’s ability to publish this in an academic journal. The investigators will make it clear that participation in this study is strictly voluntary and that failing to participation will not carry any repercussions.

What am I being asked to do?

You will be asked to report to the Human Performance Laboratory on 5 occasions. Twenty four hours prior to each visit, we ask that you refrain from the consumption of alcohol, caffeine, and over-the-counter drugs. Prior to each visit, please consume an additional 32 oz. (4 cups) of water the night before your arrival and 16 oz (2 cups) 2-3 hours prior to arrival.

**Information Visit (visit 1: ~1.5 hours)**

You are asked to report to the Human Performance Laboratory for an information visit which will include signing an informed consent and being briefed on the insertion of a nasogastric tube which the researchers will use during the experimental trials. This technique is used in hospitals to infuse fluids and is a very common, safe technique. The researcher that will be inserting the tube is trained and authorized by a licensed professional nurse.

The researchers will explain the insertion and extraction of the tube as well as the protocols used in the experimental trials for fluid infusion. During this first visit, you will be able to attempt the insertion of the tube as well as provide feedback of the perception of the tube light during exercise. The nasogastric tube is very light and thin (10 fr) and is extremely flexible. Prior to the insertion, a small amount of local anesthetic will be applied to your nasal cavity as well as a small amount of lubricant (KY Jelly) to the nasogastric tube as well as a small amount of lidocaine to your nasal entry way to lightly anesthetize the area. Following this, the researcher will insert the nasogastric tube into one of your nostrils at a pace that is comfortable for you. During this time, we ask that you take small sips of water to bypass the gagging reflex and aid in the insertion. Once the tube is properly inserted, a small amount of gastric fluid will be extracted to insure proper placement and tested for pH. The researcher will then ask how you are feeling at the moment and will ask if it will be possible for you to cycle with the nasogastric tube inserted.

During this visit, you will also be filling out questionnaires regarding your medical history and physical activity level. Your body mass, height, and body composition (Dual energy X-Ray absorptiometry DXA) will be measured. You will then be asked to perform an exercise test to determine maximal oxygen consumption (VO2max). This will occur on electronically braked ergometer (Racermate Veletron, Seattle, WA) with nose clips attached while breathing in room air and exhaling into a mouthpiece connected to a metabolic cart (Parvo Medics' TrueOne® 2400, Sandy, UT). Exercise will start at 100 watts (W) and increase 40 W every 2 minutes until volitional exhaustion. Every 2 minutes and at exhaustion, heart rate (HR) will be measured.
**Familiarization Trial (visit 2: ~3 hours)**

At least 24 hours following the information visit, you will be asked to perform a familiarization visit to familiarize yourself with the experimental protocol. During this visit, you will exercise on an electronically braked cycle ergometer for 2 hours in a warm environment (35°C) at a moderate intensity (65% VO2max). Following this 2 hour exercise bout, you will then complete a 5 km time trial performance test. The main purpose of this familiarization visit to is to introduce you to the experimental protocol. During this visit you are permitted to drink as much as you want from your water bottle. No other experimental measures will be taken.

**Experimental Trial (visit 3-5: ~3.5 hours)**

At least 7 days following the familiarization visit, you will then perform a series of experimental trials. All experimental trials will be separated by 7 days to ensure proper recovery. Upon arrival, you will void your bladder and provide a small urine sample. We will measure the concentration of the urine to make sure you are well hydrated. We will then provide you a private bathroom in which you will undress and measure your body weight. We will ask that you to insert a rectal thermocouple 10 cm past the anal sphincter for the measurement of core body temperature. This measurement is a valid, safe, and comfortable technique for measuring core body temperature. You will then guide a nasogastric tube through one nostril into your stomach. The placement of the tube will be pre-measured using the length (in cm) of the distance from the tip of the nose, behind one ear, to the tip of the sternum as a guide, and placement will be confirmed with a stethoscope by the sound of gas bubbles blown into the syringe. After the correct gastric position is confirmed, the external portion of the gastric tube will be taped to your nose and then run over your left ear and toward their left shoulder. You will be instrumented with skin temperature thermocouples (iButtons; Maxim Integrated) taped on the right side of the body at four sites (calf, upper thigh, arm, and chest). A heart rate monitoring device will then be applied to the other arm.

We will then ask you to rest in a seated position to allow body fluid homeostasis. We will then instruct you on how to guide a nasogastric tube through your nostril to your stomach. For the aid and comfort of the insertion, a small amount of lidocaine ointment will be applied with a Q-tip in your nostril. Also KY lubricant will be applied on the nasogastric tube to facilitate entry. This nasogastric tube is a common, safe technique for administering fluids. We will then tape the exterior portion of the tube to your nose, and then run the tube over your left ear and over your left shoulder for comfort purposes. To avoid discomforts the pediatric size (very thin) tubes will be used.

Following the instrumentation, you will then mount the cycle ergometer and a small blood sample (15 mL) will be obtained from your antecubital vein via venipuncture. You will then cycle on an electronically braked cycle ergometer for 120 min at 65% VO2 max, which is a moderate intensity. You will conduct this a total of 3 times over the course of your visits. Throughout the experimental protocols, the researchers will ask you perceptual questions dealing with your thirst, stomach fullness, and mouth dryness. Oxygen consumption (VO2) will also be measured during exercise. This requires that
periodically during the exercise that you breathe into a small mouthpiece to measure the oxygen and carbon dioxide your body is processing. After the 120 minutes of moderate cycling, another blood sample will be drawn (15 mL) and you will then perform a 5k time trial performance test. After the exercise bout, another small blood sample (15 mL) will be taken. You will then return to the private bathroom, remove the rectal thermometer, provide a urine sample, undress and measure your nude body weight once again. You will also remove the nasogastric tube with assistance of the research technicians, if needed.

What are the possible risks or discomforts?

There are no apparent psychological, social, legal, or economic risks to the participants.

DXA - The DXA exposes individuals to a small amount of ionizing radiation. The amount received during a DXA test is about the same as four (4) days of normal background radiation in Northwest Arkansas.

Exercise – The discomforts (i.e., muscular and systemic) due to exercise will be no greater than when individuals exercise in daily living. The aerobic test presents a physical risk because it is a brief strenuous exercise (~6 min). Strenuous exercise may cause circulatory problems in some individuals. These are infrequent (and are unlikely to occur in healthy individuals) but include abnormal blood pressure, fainting, heartbeat disorders, and in extremely rare instances a heart attack (1 in 15,000). In the unlikely event of an emergency during the test or subsequent exercise, laboratory personnel trained in CPR and the use of an AED will be present during all test sessions.

Exercise in the heat - Elevated body temperature is a normal response to exercise in the heat. Extreme body temperatures (>106°F) may result in heat illnesses such as heat exhaustion and heat stroke. We do not anticipate your body temperature to get close to this level. This risk will be minimized by monitoring your body temperature and immediately stopping exercise if you reach a dangerous level. The most valid and practical manner to measure body temperature is with rectal temperature. Heat illness in people has not been reported in carefully controlled laboratory studies such as this one. In addition to monitoring body temperature, we will educate you about the symptoms and signs of heat illness (headache, nausea, mental disorientation, lack of coordination, or dizziness) and instruct you to stop exercise if these symptoms or signs develop.

A nasogastric tube is a safe, effective way of administering fluids. During the insertion, it is normal to feel some mild discomfort in the nasal pathway as well as the pharyngeal pathway (back of the throat). To offset this, an amount of lubricant will be applied to the nasogastric tube prior to insertion. Also, a small amount of lidocaine will be applied to the areas of insertion. To avoid discomforts the pediatric size (very thin) will be used. During the insertion of the nasogastric tube, gagging sensation could be triggered that usually subsides quickly.

What are the possible benefits of this study?
Individually you will benefit by the physical conditioning received during exercise. You will also receive $150 for your participation.

How long will the study last?

You will report to the Human Performance Laboratory for 5 visits. The first visit will last 1.5 hours. The second visit will last up to 2.5 hours. The latter 3 visits will last 3.5 hours.

Will I receive compensation for my time and inconvenience if I choose to participate in this study? You will receive $150 for completing all of the experimental trials.

Will I have to pay for anything?

No. There are no costs associated with you being a participant including parking.

What are the options if I do not want to be in the study?

If you do not want to be in this study, you may refuse to participate. Also, you may refuse to participate at any time during the study. Your job, class grades, relationship with the University, etc. will not be affected in any way if you refuse to participate.

How will my confidentiality be protected?

All information will be kept confidential to the extent allowed by applicable State and Federal law. You will be assigned a code number. This code will be used during data entry and all computer programs used for analysis. All data will be locked and stored in the Human Performance Laboratory. You will not be identified in any publication or presentation of this study.

Will I know the results of the study?

At the conclusion of the study you will have the right to request feedback about the results. You may contact the faculty advisor, Stavros Kavouras, Ph.D. (kavouras@uark.edu) or Principal Researcher, Jon David Adams, M.S. (jxa014@uark.edu). You will receive a copy of this form for your files.

What do I do if I have questions about the research study?

You have the right to contact the Principal Researcher or Faculty Advisor as listed below for any concerns that you may have.

You may also contact the University of Arkansas Research Compliance office listed below if you have questions about your rights as a participant, or to discuss any concerns about, or problems with the research.

Ro Windwalker, CIP Institutional Review Board Coordinator Research Compliance, University of Arkansas 120 Ozark Hall Fayetteville, AR 72701-1201 479-575-2208 irb@uark.edu
I have read the above statement and have been able to ask questions and express concerns, which have been satisfactorily responded to by the investigator. I understand the purpose of the study as well as the potential benefits and risks that are involved. I understand that participation is voluntary. I understand that significant new findings developed during this research will be shared with the participant. I understand that no rights have been waived by signing the consent form. I have been given a copy of the consent form.