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The Effects of Energy Beverages in Counteracting the Symptoms of Mild Hypoxia at Legal General Aviation Altitudes

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THE EFFECTS OF ENERGY BEVERAGES IN COUNTERACTING THE SYMPTOMS OF MILD HYPOXIA AT LEGAL GENERAL AVIATION ALTITUDES

by

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Abstract

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The purpose of this thesis was to conduct preliminary research, in the form of a pilot study, concerning the natural effects of hypoxia compared to the effects of hypoxia experienced after the consumption of an energy beverage. The study evaluated the effects of hypoxia on FAA certificated pilots at a simulated legal general aviation altitude, utilizing the normobaric High Altitude Lab (HAL) located at Embry Riddle Aeronautical University, Daytona Beach, Florida. The researcher tested 11 subjects, who completed three simulated flight tasks within the HAL using the Frasca International *Mento*r Advanced Aviation Training Device (AATD). The flight tasks were completed after consuming Red Bull®, Monster®, or a placebo beverage. The researcher derived three test variables from core outputs of the AATD: lateral deviations from the glide slope, vertical deviations from the localizer, and airspeed deviations from the target speed of 100 knots. A repeated-measures ANOVA was carried out to determine effects of the beverages on the test variables. While results were non-significant, the researcher concluded that further research should be conducted with a larger sample.

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Chapter I

Introduction

Since the beginning of time, humans have been fascinated with the miracle of flight. As humankind has developed and technology has advanced, there has been continued pressure to go faster, make aircraft stronger, and fly aircraft higher. Humankind is obsessed with pushing machinery to its limits in the name of science, education and discovery. In the voyage of discovery, humankind has celebrated achievements in obtaining the best results possible from, not only ourselves, but also our creations (Dempsey & Gesell, 2010).

In this study, the researcher recognized that, as technologically advanced aircraft are accessible to a greater number of General Aviation (GA) pilots, it is increasingly possible to operate aircraft that are able to achieve altitudes greater than ever before. The Federal Aviation Administration (FAA) states that there is a positive correlation between altitude and fuel consumption (Federal Aviation Administration [FAA], 2012). Therefore, pilots would naturally climb to the highest altitude possible to experience the best possible performance from their aircraft. The legal limit to which a GA pilot may climb without supplementary oxygen is 14,000 feet above mean sea level (MSL) (Certification: Pilots, Flight Instructors, and Ground Instructors Rule, 2010).

FAA (2011) also notes that at altitudes as low as 5,000 feet MSL, a pilot may experience symptoms of hypoxia. Altitude-hypoxia is a condition that occurs in the body due to the reduction of air pressure as altitude increases. As a result, there is a reduction in the body's efficiency to absorb oxygen (FAA, 2011). Darwish (2003) states that the symptoms of hypoxia can be classified into five stages, which relate to the saturation of oxygen found in the body in correlation with increasing altitude. Symptoms can range from reduced night-vision in low-altitude hypoxia, to a worst-case scenario of cardiovascular collapse in high-altitude hypoxia (Darwish, 2003). However, each individual has his or her own tolerances to hypoxia, which can result in different levels of severity of symptoms (Darwish, 2003).

Low-altitude hypoxia, as defined by Darwish (2003), is also noted by FAA (2011) to occur between “12,000 to 15,000 feet MSL of altitude” in which “judgment, memory alertness, coordination and ability to make calculations are impaired, and headache, drowsiness, dizziness and either a sense of well being (euphoria) or belligerence occur” (p. 922). The researcher conducted an interview regarding low-altitude hypoxia with Dr. C. Howell, an expert in Aviation Human Factors, Human Physiology, Aviation Safety, Crew Resource Management, Situational Awareness, and NextGen General Aircraft (Embry-Riddle Aeronautical University [ERAU], 2012). Dr. C. Howell suggested that energy beverages could potentially reduce the symptoms experienced in a low-altitude, hypoxic environment. He based this statement on his personal observations noted when flying his own aircraft at the upper legal limits (Dr. C. Howell, personal communication, November 15, 2010). Energy beverages have a range of active ingredients, which have been reputed to improve mental focus, increase oxygen intake, and improve alertness (Smit & Rogers, 2002). The researcher was interested in discovering whether energy beverages could have an effect on a pilot when in a low-oxygen environment.

Through the compulsory education required in achieving any level of pilot qualification, pilots should be aware of all elements of hypoxia. However, many pilots may be unaware of the severity of the dangers found in the symptoms of hypoxia. The guidelines surrounding altitudes where hypoxia may occur are diverse and often inconsistent, even among the publications produced by the regulatory control bodies. The researcher was interested in whether consuming an energy beverage before flight could result in a reduction of the symptoms of hypoxia at altitudes where there is potential for hypoxia.

Significance of the Study

This study holds great importance, as currently the only mention of beverages as prescribed for GA pilots by the US government concerning alcohol consumption (FAA, 2011). This study covered areas of research where the outcome could be significant for pilots, the FAA, and Aero-Medical boards. Therefore, the study could produce a safety recommendation for pilots to take precautions against the symptoms of hypoxia through the consumption of an energy beverage.

The rules published by the FAA suggest that GA pilots may fly as high as 12,500 feet MSL any time, and up to 14,000 feet MSL for 30 minutes, without a requirement for supplementary oxygen (Supplemental Oxygen Rule, 2010). However, the FAA also states that the effects of hypoxia can be present at an altitude of 5,000 feet MSL at night (FAA, 2011). Therefore, it is important that pilots can recognize hypoxia, the potential dangers, and possible ways of counteracting its symptoms. Research suggests that hypoxia can affect individuals differently, depending on their individual tolerances and general condition of health (Darwish, 2003). The variable factors are smoking, weight, alcohol consumption, fitness, and prescribed medication (FAR, 2011).

It was noted by an experienced pilot that there was an observed decrease in the recognized effects of hypoxia from flying at altitudes between 10,000 and 14,000 feet

MSL when consuming an energy beverage before flight. Upon further exploration it was discovered that the positive effects of energy beverages have been evaluated in scenarios related to driving (Mets et al., 2010), concentration (Smit & Rogers, 2002), and in research on armed forces personnel, but not in relation to flying (Tharion, Montain, O'Brien, Shippee, & Hoban, 1997). Since there has been no research regarding energy beverages and low-altitude hypoxia, the researcher believed there was an opportunity for research which would be of interest to the aviation community.

Statement of the Problem

The FAA prescribes regulations about the acceptable altitudes where a GA pilot may fly unaided by supplementary oxygen or pressurization. It is apparent that there are differences between these regulations and other regulations. For example, the Supplemental Oxygen Rule (2010), which is the guideline for most GA pilots, states that pilots may fly up to but not including 12,500 feet MSL, without supplementary oxygen. The Supplemental Oxygen Rule (2010) also states that a pilot may fly between 12,500 feet MSL and 14,000 feet MSL for 30 minutes without supplemental oxygen before returning to below 12,500 feet MSL, and a pilot must use supplemental oxygen to fly above 14,000 feet MSL. However, the Aircraft Certification and Equipment Requirements Rule (2010), for Part 121 carriers, states that crewmembers must be on supplemental oxygen at all times above 12,000 feet MSL. This is regardless of the period of time they are above the altitude and notably stricter than the rules prescribed by the Supplemental Oxygen Rule (2010). The Pilot Requirements: Use of Oxygen Rule (2010) for Part 135 carriers states that, in the case of unpressurized aircraft, a pilot must use oxygen above 10,000 feet MSL through 12,000 feet MSL if longer than 30 minutes in duration, and at all times above 12,000 feet MSL.

In addition to the differences in the prescribed rules regarding altitude, it is also suggested that all pilots would be equally affected by low-altitude hypoxia. However, it is documented by FAA (2011) that pilots have varying tolerances to hypoxia. The researcher believed there could be issues arising from inconsistencies in the prescribed rules regarding altitude, and a possibility that some pilots may experience varying severity of symptoms. It was therefore important to analyze whether and to what extent an energy beverage could potentially help pilots to cope with the symptoms of hypoxia when operating at the upper legal limits of the prescribed rules.

Purpose Statement

The purpose of this study was to determine the effects of an energy beverage on symptoms of hypoxia by simulating the legal flight altitude of 14,000 feet MSL and exposing subjects to the symptoms of low-altitude hypoxia. The researcher provided the subjects with energy beverages and a placebo to evaluate whether there were any effects on possible symptoms of mild hypoxia.

Hypothesis

The following hypothesis was tested: There will be a difference in the effects of hypoxia between pilots who consumed an energy beverage before completing a simulated instrument approach at a simulated altitude of 14,000 feet MSL and pilots who did not, among college students at Embry-Riddle Aeronautical University, Daytona Beach, Florida Campus.

Delimitations

The subjects were self-elected students of Embry-Riddle Aeronautical University, Daytona Beach, Florida campus. The students were between 18-30 years of age and had maintained a pilot's license with an instrument rating and at least a second-class medical certificate at the time of testing.

The researcher exposed the subjects to the simulated upper legal limit of 14,000 feet MSL to enhance the possibility that the symptoms of low-altitude hypoxia would be present. The subjects remained at the simulated 14,000 feet MSL altitude for the entire testing phase. The testing phase did not exceed the legal limit of 30 minutes. The researcher evaluated whether the energy beverage had an effect on the subjects' performance in respect to lateral deviations, vertical deviations, and airspeed deviations while performing a simulated instrument approach.

The subjects were limited to performing the simulated flight tasks utilizing the Frasca™ *Mentor* Advanced Aviation Training Device (AATD) (Frasca International, 2011). The AATD was used to test the subjects' performance while flying an instrument approach in a typical GA aircraft.

The testing was limited to the normobaric High Altitude Lab (HAL). The HAL was capable of simulating an environment which is consistent with being at 14,000 feet MSL (Colorado Altitude Training [CAT], 2009).

Limitations and Assumptions

The subjects were required to complete three separate test sessions, in which they consumed a different beverage each time. The subjects did not know which beverage they were consuming at each test session; however, they were aware of the range of ingredients in all beverages. Subjects were blind to the beverage type to eliminate any psychological effect on subjects' performances.

The subjects were also not aware of the altitude that the HAL was simulating. As previously stated, the experiment never exceeded the altitudes defined by FAA regulations in the Supplemental Oxygen Rule (2010). The altitude showed a constant 14,000 feet MSL; however, the HAL has a 1-3% level of error, and as such cannot keep to 14,000 feet MSL constantly (CAT, 2009).

The method of recruiting the subjects did not allow the researcher to select subjects with similar attributes such as skill and qualification level, height, weight, gender etc.; therefore, the researcher did not expect to observe a pattern of similar results. The subjects were given a pre-test survey, and the accuracy of this survey was dependent on the subjects' willingness to be honest. It was assumed that the subjects were forthright in completing the pre-test survey.

It was assumed that the lab technicians were accurate in following the methods and procedures of research and conducted the experiment the same way for every subject. It was assumed that the accuracy of the instruments was consistent for all of the tests.

Definitions of Terms

14 CFR § 91 - Section of the CFRs that covers general operations of aircraft in the Airspace System (General Operating and Flight Rules, 2010)

14 CFR § 121 - Section of the CFRs that covers scheduled air carrier's operations in the Airspace System (Operating Requirements: Domestic, Flag, and Supplemental Operations Rules, 2010).

14 CFR § 135 - Section of the CFRs that covers non-scheduled air carrier's operations in the Airspace System (Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons On Board Such Aircraft Rules, 2010)

Blood Oxygen Content - A measure of how many O_2 molecules are in the blood. Measured as a percentage of a 100% total (FAA, 2011)

Dot – Unit of measurement used to represent a deviation from the glide slope, equal to 200 feet MSL (FAA, 2011)

Hypobaric - A decrease in atmospheric pressure in relation to normal ambient pressure (FAA, 2011)

Hypoxia - A state of having less oxygen than required for normal bodily and cognitive function. (FAA, 2011)

Hypoxic Hypoxia - The effect that is caused by a lack of atmospheric pressure. This lack of oxygen in the body is due to the inability of the oxygen to cross through the membrane of the lungs into the blood stream. (FAA, 2011)

Normobaric - Standard Sea Level Pressure in relation to the lab (FAA, 2011)

List of Acronyms

AATD	Advanced Aviation Training Device
AC	Advisory Circular
ADM	Aeronautical Decision Making
AGL	Above Ground Level
AIM	Aeronautical Information Manual
ASMA	Aerospace Medical Association
BPM	Beats Per Minute

CAT	Colorado Altitude Training
CFR	Code of Federal Regulations
DCS	Decompression Sickness
DoD	Department of Defense
DoT	Department of Transportation
EEG	Electroencephalogram
ERAU	Embry-Riddle Aeronautical University
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
GA	General Aviation
GS	Glide Slope
HAL	High Altitude Lab
IAS	Indicated Air Speed
ILS	Instrument Landing System
IRB	Institutional Review Board
MSL	Mean Sea Level
NTSB	National Transportation Safety Board
SL	Sea Level
SpO2	Saturation of Oxyhemoglobin
TUC	Time of Useful Consciousness

Chapter II

Review of the Relevant Literature

The researcher consulted the regulatory sources to ensure that this research would be in accordance with regulated pilot rules. The legislation was used to identify rulings for pilots subjected to an unpressurized environment and without supplemental oxygen, where hypoxic symptoms may occur. The rules regarding the level of exposure a pilot may have to a reduced oxygen environment were consulted to ensure that the experiment would be designed and conducted correctly, thus protecting the subjects from harm and producing results that would be relevant to potential real life scenarios (Supplemental Oxygen Rule, 2010).

FAA Regulations

The FAA is the governing body for all aspects of civil aviation in the United States. The primary responsibility of the FAA is to regulate the Civil Aerospace system in the US for both domestic and international pilots and aircraft (FAA, 2011). The FAA also regulates the air traffic control facilities, controls certification for pilots and aircraft, and promotes safety. The promotion of safety is achieved by reducing risk through regulations.

The Code of Federal Regulations (CFR) is the framework and codification for the rules that are published through the Federal Register on behalf of the Executive Departments of the Federal Government ("Code of Federal Regulations" [CFR], 2010). The CFRs are sectioned into 50 titles and represent all major departments and agencies within the FAA. The titles are then divided further into chapters, which are then subdivided into parts (CFR, 2010).

For the purpose of this study, the applicable *Title 14: Aeronautics and Space* was of interest, in particular, Part 91, the General Operating and Flight Rules (2010). Under Subpart C, *Equipment, Instrument and Certificate Requirements*, the rules on operating a U.S. registered aircraft are specified. The rules found under Part 91, Subpart C, govern most GA pilots and state that no person may operate outside of these conditions. The code states:

> No person may operate a civil aircraft of U.S. registry—
>
> (1) At cabin pressure altitudes above 12,500 feet MSL up to and including 14,000 feet MSL unless the required minimum flight crew is provided with and uses supplemental oxygen for that part of the flight at those altitudes that is of more than 30 minutes duration.
>
> (2) At cabin pressure altitudes above 14,000 feet MSL unless the required minimum flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes.
>
> (3) At cabin pressure altitudes above 15,000 feet MSL unless each occupant of the aircraft is provided with supplemental oxygen. (Supplemental Oxygen Rule, 2010).

The ruling for GA is, in fact, more relaxed compared to Part 121, regarding Supplemental Oxygen: Reciprocating Engine Powered Airplanes Rule (2010) that governs scheduled air carriers. The effects of hypoxia do not tend to be a problem for passengers and crew because the aircraft are pressurized; whereas, most GA aircraft do not operate with a pressurized cabin. For Part 121 operators the guidelines state:

> (1) At cabin pressure altitudes above 10,000 feet MSL up to and including 12,000 feet MSL, oxygen must be provided for, and used by, each member of the flight crew on flight deck duty, and must be provided for other crewmembers, for that part of the flight at those altitudes that is of more than 30 minutes duration.
>
> (2) At cabin pressure altitudes above 12,000 feet MSL, oxygen must be provided for, and used by, each member of the flight crew on flight deck duty, and must be provided for other crewmembers, during the entire flight time at those altitudes. (Supplemental Oxygen: Reciprocating Engine Powered Airplanes Rule, 2010, p. 327).

The Supplemental Oxygen: Reciprocating Engine Powered Airplanes Rule (2010) suggests it may be possible to experience symptoms of hypoxia as low as 10,000 feet MSL. The same rules are outlined in the Pilots Requirements Rule: Use of Oxygen (2010) which concerns all those who operate under Part 135. The Pilots Requirements Rule (2010) states that all pilots of unpressurized aircraft must carry supplemental oxygen for use when operating above 12,000 feet MSL, or between 10,000 feet MSL to 12,000 feet MSL if longer than 30 minutes. In Part 121 and Part 135, the passengers and crew are the number one priority for safety, hence the stricter rules. Therefore, the FAA may feel it necessary to use tighter tolerances despite no immediate danger from a hypoxic environment.

Hypoxia

The FAA *Aeronautical Information Manual* (AIM) is published annually by the Department of Transportation (DOT) as a quick reference guide (FAA, 2011). It covers all necessary data required by GA pilots, sports pilots and instructors in an easy-to-find-format. Relevant information is described below.

Symptoms of hypoxia. FAA (2011) provides medical facts for pilots, including information on hypoxia. It defines hypoxia:

(1) Hypoxia is a state of oxygen deficiency in the body sufficient to impair functions of the brain and other organs. Hypoxia from exposure to altitude is due only to the reduced barometric pressure encountered at altitude, for the concentration of oxygen in the atmosphere remains about the 21 percent from the ground out to space.

(2) Although deterioration in night vision occurs at cabin pressure altitudes as low as 5,000 feet, other significant effects of altitude hypoxia usually do not occur in the normal healthy pilot below 12,000 feet. From 12,000 to 15,000 feet of altitude, judgment, memory, alertness, coordination and ability to make calculations are impaired, and headache, drowsiness, dizziness and either a sense of well being (euphoria) or belligerence occur. The effects appear following increasingly shorter periods of exposure to increasing altitude. In fact, pilot performance can seriously deteriorate within 15 minutes at 15,000 feet. (FAA, 2011, p. 922).

The FAA states that the effects of altitude hypoxia are, in fact, due to changes in barometric pressure and not due to the lack of oxygen in the air, as endorsed by the Aerospace Medical Association (ASMA) (FAA, 2011).The ASMA is highlighted as being a resource to help recognize the effects of hypoxia. It advises that pilots undertake a physiological training program to become more knowledgeable in recognizing the symptoms of hypoxia (FAA, 2011).

According to the FAR, the effects can be present as low as 5,000 feet MSL at night and from 12,000 feet MSL during the day, and that supplemental oxygen should be carried at these altitudes (FAA, 2011).

The FAA (2011) explains that the symptoms of hypoxia can be more significant among smokers and if carbon monoxide is inhaled from the exhaust. Other accelerators of the symptoms can include the presence of small amounts of alcohol in the body, certain prescription drugs, cabin temperature, colds, fevers, or anxiety (FAA, 2011). The FAA concludes by stating that the effects of hypoxia are extremely difficult to recognize without proper training. In order for GA pilots to be fully protected, the FAA suggests supplemental oxygen be used when operating above 10,000 feet MSL during the day, and 5,000 feet MSL at night (FAA, 2011).

Symptoms of hypoxia are difficult to identify, and it is pertinent to highlight that the symptoms vary in severity depending on the stage of onset (FAA, 2011). There are four levels of hypoxia, and each one has a set of symptoms related to the saturation of oxygen in the body. Darwish (2003) defines the stages as listed in Table 1.

Table 1

Symptoms of Hypoxia

Stages	Indifferent (99%-95% O2 saturation)	Complete Compensatory (94%-85% O2 saturation)	Partial Compensatory (84%-70% O2 saturation)	Critical (69% and lower O2 saturation)
Altitude (thousands of Feet MSL)	0-5	5-11	11-18	Above 18
Symptoms	Decrease in night vision	Tingle behind throat	Impaired vision	Circulatory failure
		Impaired situational awareness	Impaired flight control	Convulsions
		Euphoria	Impaired Judgment	Cardiovascular collapse
		Drowsiness	Impaired efficiency	Death
		Poor judgment	Impaired handwriting	
			Impaired speech	
			Decreased coordination	
			Decreased sensation to pain	
			Decreased memory	

Note. Adapted from "Aerospace Medicine: *Part 1*," by A.A. Darwish, 2003, *The Internet Journal of Pulmonary Medicine, 3* (2), p. 16.

The stages highlighted by Darwish (2003) are defined as those experienced by an average healthy pilot. However, as denoted by FAA (2011), individuals have different tolerances to hypoxia. As a result, it is assumed that an individual may experience more severe symptoms at a lower altitude than described in Table 1.

A study to evaluate the effects of hypoxia on pilot performance at GA altitudes was conducted by the FAA (Nesthus, Rush, & Wreggit, 1997). The purpose of that study was to analyze whether symptoms of hypoxia were present under the prescribed 12,500 feet MSL, given that individuals can show varying tolerances. Nesthus et al. (1997) defined hypoxia as “a state of oxygen deficiency in the blood, cells, or tissue of the body sufficient to cause an impairment of function” (p. 12). Nesthus et al. (1997) noted:

> In aviation, a reduction in total atmospheric pressure occurs with increasing altitude. This change produces a reduction of oxygen partial pressure (P_{O2}) and hence, a reduction of alveolar Oxygen Pressure *and* the pressure gradient between the alveoli and mixed venous blood in the pulmonary capillaries. By breathing the ambient air of a reduced pressure environment, less oxygen diffuses across the alveolar-capillary membranes into the blood stream and to the tissues of the body. (p. 13)

Nesthus et al. (1997) also asserts that the body requires a constant level of oxygen intake if it is to function correctly, and that the brain uses one-fifth of the oxygen we consume. This is compared to the fact that the brain only represents 2% of the body’s total weight (Nesthus et al., 1997).

The brain’s ability to function correctly was analyzed further in a neurophysiology article relating to the topographic changes due to hypobaric hypoxia at simulated altitudes (Ozaki, Watanabe, & Suzuki, 1995). Ozaki et al. (1995) tested brain activity against its sensitivity to oxygen supply by measuring the electrical activity and functional state when hypoxic. The results showed that, as altitude increased, the influences of hypoxia affected the physiological parameters (Ozaki et al., 1995). The 12,000 feet MSL stage results of the experiment were most applicable to the 12,500 feet MSL upper legal limit (more than 30 minutes) prescribed by the FAA for GA pilots without the need for supplemental oxygen (FAA, 2011). The results showed the brain's cognitive function significantly decreased at 12,000 feet MSL, compared to sea level (Ozaki et al., 1995). Ozaki et al. suggested that the first stage of hypobaric hypoxia is caused by suppression of alpha Electroencephalogram (EEG) activity. However, these effects can be skewed by the pilot's skill level and tolerances to the effects of hypoxia (Ozaki et al., 1995), which are further discussed by Fiorica, Burr, and Moses (1977). Fiorica et al., (1977) explored how pilots can perform vigilance tasks at an equivalent flight level of 11,500 feet MSL. Despite the results proving to be statistically insignificant, pulse-oximeter readings taken from the pilots revealed a concerning saturation in their blood oxygen levels and deterioration in vigilance performance (Fiorica et al., 1977). However, the nature of the experiment was reported as being too simple and requiring minimal muscular activity; therefore, it was suggested that the patterns seen would have been far more severe if the vigilance indicators had been more sophisticated (Fiorica et al., 1977).

Energy and Sports Beverages

For the purpose of this study, it is important to note that energy and sports beverages are defined as two separate beverage types as classified by Kotke and Gehrke (2008). The purpose of an energy drink is to provide the consumer with a burst of energy via a cocktail of ingredients that stimulate the body to become more alert and active

(Kotke & Gehrke, 2008). The energy drink is also marketed for mental stimulation effects as denoted by Amendola, Iannilli, Restuccia, Santini, and Vinci (2004). A sports drink is targeted at athletes, with a purpose of rehydrating the athlete and replenishing energy and nutrients lost with sugars, vitamins and minerals (Kotke & Gehrke, 2008).

Core active ingredients in energy beverages. Most energy drinks contain herbal supplements, such as Guarana, Yerba Mate leaves, Pannax ginseng, ginko biloba, and milk thistle (Kotke & Gehrke, 2008). The most common active ingredient found in energy beverages is caffeine, which has various doses based on the exact type and marketed audience of the product (Kotke & Gehrke, 2008). Typically, the variation of caffeine ranges from 2.5 mg to 171 mg per fluid ounce (Reissig, Strain, & Griffiths, 2008). Caffeine, a central nervous system stimulant, is claimed to improve alertness and reaction times (Kotke & Gehrke, 2008). Other studies have shown caffeine increases long-term athletic performance and improves speed and power output (Reissig et al., 2008). Additionally, caffeine has been attributed to improving mental function and efficiency on vigilance tasks (Reissig et al., 2008).

Taurine is the second most commonly found key active ingredient in energy beverages (Amendola et al., 2004; Kotke & Gehrke, 2008). Taurine lowers the heart rate and noradrenalin concentration, according to Gershon, Shinar, and Ronen (2009), and is used in the beverages to balance the caffeine intake. Deixelberger-Fritz, Tischler and Wolfgang (2003) found that the consumption of a Red Bull® did not raise the subjects' heart rates, which was attributed to the equilibrium produced from Taurine.

Other ingredients commonly found in energy and sports drinks include carbohydrate-electrolyte compounds (Amendola et al., 2004; Kotke & Gehrke, 2008).

The purpose of the carbohydrate-electrolyte compound is to provide a boost of energy to muscles and improve performance (Amendola et al., 2004). There are 14 common nutritional factors in these compounds including calories, total carbohydrates, sugars, sodium, potassium, magnesium, vitamin C, vitamin A, vitamin E, niacin, vitamin B12, pantothenic acid, and thiamine (Amendola et al., 2004).

The electrolytes found in sports and energy beverages are sodium, potassium, and magnesium, all of which are lost through perspiration (Amendola et al., 2004). The metabolic heat that is produced when the body is under stress is shown to be lost by radiation, conduction, convection and vaporization of water, where evaporation accounts for 80% of metabolic heat loss (American Dietetic Association, 2000). In addition to water, sweat also contains substantial amounts of sodium, modest amounts of potassium, and small amounts of minerals such as iron and calcium (American Dietetic Association, 2000). The benefits of adding sodium to a beverage are outlined by Amendola et al., (2004) who stated that sodium plays a key role in the body's ability to ingest fluid, retain water, and replenish lost nutrients. The benefits of potassium and magnesium in beverages are as a supplement, which helps prevent the body from cramping to maintain optimum muscle performance (Amendola et al., 2004).

Amendola et al. (2004) claim the vitamins in the beverages are beneficial for energy production and protein metabolism. The vitamins in sports and energy beverages are most beneficial when the vitamins are not produced naturally to a sufficient level, typically at times when the body is under increased mental and physical stress (Amendola et al., 2004). When the body is under increased mental and physical stress, it may show sub-optimal metabolism and decreased performance (Amendola et al., 2004). Vitamins and minerals are also related to the repair function of the body (American Dietetic Association, 2000). Stresses on the body affect the metabolic pathways, which increase micronutrient needs (American Dietetic Association, 2000).

B vitamins are also commonly found in high doses in energy beverages (American Dietetic Association, 2000). The American Dietetic Association (2000) states that B vitamins have two major functions: the production of energy and the regulation and production of red blood cells for protein synthesis and tissue repair. Vitamins A, E, and C, beta-carotene, and selenium help protect the body against oxidative damage (American Dietetic Association, 2000). At times of elevated mental and physical stress, oxygen requirements can increase by 10 -15 times; therefore, the body requires large amounts of B vitamins to handle the stress placed on it (American Dietetic Association, 2000).

Effects of energy beverages. The effects of the ingredients found in energy drinks have been increased cognitive performance, alertness, mood, and mental performance (Deixelberger-Fritz et al., 2003). In a study by Deixelberger-Fritz et al. (2003), the energy drink, Red Bull®, was evaluated. Thirty-two subjects were subjected to a mental performance test after consuming the energy beverage. The participants included 24 pilots and 8 non-pilots. The results demonstrated "clear-cut positive effects of the energy drink on choice reaction time and on the performance in a concentration test," at a .05 significance level (Deixelberger-Fritz et al., 2003, p.23). Deixelberger-Fritz et al. (2003) found that the positive effects were sustained for two hours post-consumption and do not coincide with research based on the consumption of just caffeine. Therefore, Deixelberger-Fritz et al. (2003) concluded that the effects are produced by the cocktail of ingredients found in the energy beverage. The study by Deixelberger-Fritz et al. (2003) allowed for a wash period of 24 hours to avoid potential residual effects; however, it was noted that performance was still increased by the pilots on the second day, which was potentially due to a learning effect.

In another study utilizing energy drinks by Gershon et al. (2009), Red Bull® was evaluated in a driving simulator scenario to counteract fatigue, and the results produced positive effects. The results showed that the consumption of the energy beverage prior to completing a simulated driving task increased subject alertness (Gershon et al., 2009). The findings by Gershon et al. (2009) suggested that the absorption of caffeine reaches its maximal blood levels between 30-45 minutes post-consumption. The quick metabolism of energy beverages is endorsed in a further study by Brain Research (2010) on energy beverages consumed by sprinters and cyclists. In this study, Brain Research (2010) claimed that energy beverages take an almost immediate effect, due to a neural pathway connecting the tongue to muscles. Brain Research (2010) stated that the participants had a 30% increased neural response following the consumption of an energy beverage compared to the placebo.

There were further positive effects found from consuming an energy beverage as a countermeasure to fatigue, following another driving scenario-based study by Reyner and Horne (2002). Reyner and Horne (2002) concluded that the consumption of an energy beverage was beneficial in reducing sleep-related incidents and improved subjective concentration. The responsible agents were identified as caffeine and Taurine in combination (Reyner & Horne, 2002).

A study testing night-shift workers, completed by Jay, Petrilli, Ferguson, Dawson, and Lamond (2006), attempted to establish if there were negative residual effects on subsequent sleep post-consumption of an energy beverage. Jay et al. (2006) concluded that the consumption of an energy beverage helped the participants' ability to stay alert, and did not affect the participants' ability to achieve a slow-wave sleep, compared to a control group. Additionally, sleep-onset latency was not affected.

Two separate studies were conducted by Scholey and Kennedy (2004) and Smit and Rogers (2002) on mental performance, cognitive, and physiological effects following the consumption of an energy beverage. Smit and Rodgers (2002) discovered that the subjects who consumed energy beverages displayed clear-cut positive results on mood and reaction times. The results showed that there were “energizing, alerting and revitalizing effects of the two test beverages compared to water” (Smit & Rodgers, 2002, p. 9). These effects were reported to have lasted the duration of the test session, 100 minutes (Smit & Rodgers, 2002). Smit and Rodgers (2002) also reported that the effects were present in the participants on an average of 38 minutes post-consumption.

Similarly, Scholey and Kennedy (2004) stated that the subjects demonstrated improved cognitive performance following the consumption of an energy drink. The results showed that, in comparison to the placebo, there were improvements in secondary memory and speed of attention among the subjects (Scholey & Kennedy, 2004). Under all testing conditions, Scholey and Kennedy (2004) revealed a net improvement in performance. The study's secondary conclusion stated that the cognition-enhancing properties of the energy beverage cannot be solely attributed to the caffeine, but more likely a combination of all of the ingredients (Scholey & Kennedy 2004).

Normobaric High Altitude Lab

The normobaric HAL is a beneficial tool for pilot training, and as such, the FAA recognizes it as a training instrument for improving pilot safety (CAT, 2009). The HAL enables a person to experience the effects of a simulated altitude environment without the need for decompression, as necessary with a hypobaric chamber (CAT, 2009).

A hypobaric chamber reduces the pressure within it to simulate the environment of the standard atmosphere at an elevated altitude (CAT, 2009). As a result, the chambers are often small and are costly to operate due to the pressure requirements. One negative of hypobaric chambers is that the subjects are at risk of decompression sickness, and cannot return to work or fly for several hours after testing (CAT, 2009).

As an alternative to the hypobaric chamber, the normobaric HAL is often a preferable instrument for training, as pilots are able to return to work immediately without risk of developing decompression sickness, as it retains the same barometric pressure as sea-level (CAT, 2009). Another alternative to the HAL is the Hypoxic Mask-Based system (Self, Mandella, Prinzo, Forster, & Shaffstall, 2010). The mask-based-system is a portable device that enables the user to experience a hypoxic environment through breathing gas with reduced oxygen and increased nitrogen (Self et al., 2010). The mask has limited side effects, allowing the user to fly almost immediately afterward (Self et al., 2010). However, some research questions the reliability of the mask as it can affect the subjects' breathing pattern (Self et al., 2010).

The normobaric HAL was a concept designed by Professor Glen Harmon at ERAU and to date remains one of a handful in the world (CAT, 2009). The normobaric HAL uses oxygen scrubbers to remove oxygen from the atmosphere within the lab and can simulate up to 30,000 feet MSL without a change in pressure (CAT, 2009). Harmon states that symptoms observed in the HAL can include "tunnel vision, dizziness, tingling, fatigue, and loss of coordination;" therefore, the lab is used to help train pilots to recognize how they are individually affected by a hypoxic environment (CAT, 2009).

Frasca International Mentor Advanced Aviation Training Device

The Frasca International *Mentor* Advanced Aviation Training Device (AATD) is an FAA-endorsed fixed position flight simulator (Frasca, 2011). It allows pilots to experience a glass-cockpit flight arrangement (Frasca, 2011). The *Mentor* is specifically designed to allow pilots an opportunity to fly aircraft with advanced avionics equipment such as the Garmin G1000 suite (Frasca, 2011). The *Mentor* is fully programmable and contains a Graphical Instructor Station (GIST) allowing the researcher the ability to set up any number of flight procedures for the subject to complete (Frasca, 2011). The accuracy of the *Mentor* is endorsed by the FAA, specifically in terms of both the FAA-approved AATD and the FAA-approved flight data package (Frasca, 2011).

Pulse Oximeter

The pulse oximeter is an important lab tool, as it allows the researcher the ability to test the subjects' pulse rate and SpO2% saturation levels; which, when combined, give the researcher an accurate reading of the subjects' blood oxygen levels (Tremper, 1989). The ability to read a subject's SpO2% levels and beats per minute (BPM) saturation levels is of great importance, as it allows the researcher to gauge whether the subject is in one of the four levels of hypoxia as defined by Darwish, (2003). This is pertinent to both the study and the safety of the subject. The HAL utilizes the Nonin fingertip pulse-oximeter to provide fast and accurate blood oxygen level readings (Nonin, 2011). The accuracy of the Nonin Onyx used in the HAL was endorsed by achieving a U.S. Army and U.S. Air Force aero-medical certification (Nonin, 2011). Nonin (2011) states:

> The Onyx is ideal for use in any situation where a fast and accurate reading of blood oxygen saturation and pulse rate is needed. Never search for a pulse oximeter or sensor again. The portability and functionality of the Onyx makes it a valuable tool in any situation where a fast and accurate reading of blood oxygen saturation and pulse rate is needed. (p. 19)

Summary

Part 91, the General Operating and Flight Rule (2010), states that in an un-pressurized cabin a pilot may only fly between 12,500 feet MSL and 14,000 feet MSL for a maximum of 30 minutes without supplemental oxygen. The General Operating and Flight Rule (2010) also states that, at altitudes above 14,000 feet MSL, the flight crew must be provided with and use supplemental oxygen; and at altitudes above 15,000 feet MSL, every occupant must be provided with supplemental oxygen.

Part 121, the Supplemental Oxygen: Reciprocating Engine Powered Airplane Rule (2010), states that in an unpressurized cabin, supplemental oxygen must be provided if operating at altitudes above 10,000 feet MSL, up to and including 12,000 feet MSL for more than 30 minutes. Part 121, the Supplemental Oxygen: Reciprocating Engine Powered Airplane Rule (2010), also states that above 12,000 feet MSL each member of the flight crew must be provided and use supplemental oxygen for the entire flight. Under Part 135, the Pilots Requirements Rule: Use of Oxygen (2010), states that in unpressurized aircraft, oxygen must be used at altitudes above 10,000 feet MSL through 12,000 feet MSL if that part of the flight exceeds more than 30 minutes duration; and at all times above 12,000 feet MSL. The FAA (2011) states that deterioration in night vision occurs at altitudes as low as 5,000 feet MSL. The FAA (2011) also states that in normal healthy pilots at altitudes of 12,000 feet MSL and above, judgment, memory, alertness, and coordination can be impaired. From 12,000 feet MSL and 15,000 feet MSL, pilots may also experience drowsiness, dizziness, and euphoria (FAA, 2011). Darwish (2003) states that there are levels of severity in hypoxia, and that human beings have individual tolerance levels to a low-altitude hypoxic environment, which can be dependent on their condition of health.

Energy beverages have proven to be stimulants, which suggests they may have an effect on pilot performance, and may affect the symptoms found from experiencing a hypoxic environment. Caffeine is recognized as being the main active ingredient in energy beverages and can improve alertness, mental function and efficiency in vigilance tasks (Kotke & Gehrke, 2008). Taurine has been observed to actively lower the heart rate and stabilize the body's noradrenalin concentration in times of elevated mental and physical stress (Gershon et al., 2009). The American Dietetic Association (2000) states that B-vitamins assist in the body's production of energy and the regulation and production of red blood cells. Therefore, in high doses similar to the levels found in energy beverages, B-vitamins will increase the body's efficiency in the absorption of oxygen in times of elevated physical and mental stress (American Dietetic Association, 2000).

The Normobaric HAL provides a safe, accurate environment for the subjects to be tested in, without the possibility of decompression sickness (CAT, 2009). The Frasca International *Mentor* AATD is specifically designed to allow pilots an opportunity to fly a GA aircraft with advanced avionics equipment, and allows the operator the capability to program flight tasks for test purposes (Frasca, 2011). The accuracy of the *Mentor AATD* was tested by the FAA, and is approved for use as a pilot training device (Frasca, 2011). The pulse oximeter meets standards for use by the U.S. Army and Air Force (Nonin, 2011).

Chapter III

Methodology

Research Approach

The study was an experimental design that analyzed the effects of two energy beverages plus one placebo beverage against the effects of hypoxia in a group of eleven subjects. The study included comparative research to evaluate and analyze the subjects' ability to fly a standard simulated instrument approach based on the variables: vertical deviations from Glide-Slope (GS), lateral deviations from localizer, and deviations from the prescribed speed of 100 knots. The subjects were always at a simulated altitude where oxygen deprivation was present to a level that represented 14,000 feet MSL.

The study aimed to evaluate whether the energy beverages could decrease the effects of hypoxia, and change the subjects' tolerances to its effects. The altitude remained the same for all subjects; the independent variables were the energy beverages. The study was conducted within the HAL. The data was collected from the outputs of the Frasca International *Mentor* (AATD) (Frasca, 2011). The subjects were asked to conduct a simulated standard instrument approach in a typical GA aircraft.

The stimulant beverages contain the following common ingredients:

- Caffeine - The most common ingredient; it stimulates the central nervous system giving the body a sense of alertness. It can raise the heart rate to deliver more oxygen around the body (Kotke & Gehrke, 2008).
- Taurine - It helps regulate heartbeat, muscle contractions, and regulate energy levels (Kotke & Gehrke, 2008).
- Guarana – It increases alertness and energy (Kotke & Gehrke, 2008).

- B Vitamins – They help with converting food into energy, and improving the body's ability to intake oxygen into the blood (American Dietetic Association, 2000).
- Sugars – They fuel the body and increase energy (American Dietetic Association, 2000)
- The placebo was a naturally flavored carbonated water and had no active ingredients or stimulants of any kind.

Design and procedures. The experiment was fully outlined and submitted to the Institutional Review Board (IRB), where approval was required due to the use of human subjects in the experimentations (IRB Forum, 2011). Appendix A contains the IRB documentation. Upon approval, the research was advertised to participants on a first-come, first-served basis. The respondents to the advertisement were all male. The subjects were subsequently invited to an information presentation where they were informed of all the possible ingredients found in the energy beverages and the potential side effects of consuming the beverages. In addition, the subjects were provided with information about the effects of testing in a reduced-oxygen environment. By providing the subjects with the potential threats and requirements to participate, the researcher had an opportunity to screen the participants and disqualify any subjects who could not tolerate this type of testing. One subject did not qualify. In addition to pre testing, the subjects were given a briefing on the AATD (Frasca, 2011) and the tasks that they were required to perform. The subjects were split into groups and each attended three lab sessions on different days with a minimum 24-hour interval between tests.

Prior to the test, several pre-test sessions were completed by the researchers who conducted the experiment. The pre-test sessions enabled a set of procedures to be created, outlining all of the variables for each scenario and a timetable of the subjects' arrival times. The pre test session allowed the researchers to become proficient in the operation of the *Mentor* AATD and identified the test variables. Appendix D contains the HAL setup procedures.

The final test design required one researcher to be in the HAL at all times, one researcher to be directly outside the HAL, and one researcher to be in a pre-briefing room. The purpose of the researcher in the HAL was to operate the *Mentor* and to ensure the safety of the participants at all times. The researcher located directly outside the HAL was in charge of time management, monitoring the HAL instruments, and administering the pulse-oximeter tests before the subjects entered the HAL and upon exit from the HAL. The researcher in the briefing room was in charge of meeting and greeting the subjects, administering the beverages, managing time for the test sessions and ensuring they were qualified for testing. Qualification for testing was completed by the researcher, by ensuring that the subjects correctly completed the Pre Test Survey, the High Altitude Laboratory Participation Form, and the Medical Clearance Form. Appendix C contains these forms. The beverages were administered in the order of Red Bull®, Monster®, and then placebo, for each subject to coincide with test, 1, 2, 3. The approach plates tested were randomized to ensure no two subjects tested on the same approach plate consecutively. The subjects were always blind to which beverage they had consumed.

Apparatus and materials. The HAL was used as the main apparatus for manipulating the altitude. Housed within the HAL, the *Mentor* AATD was used to conduct the evaluation of a simulated flight task. The data was collected and stored on USB storage devices for security.

The HAL incorporated recording devices, including video cameras, to record the data. The researcher and the subjects in the HAL had access to oxygen in the event of an emergency.

Two energy beverages containing common active ingredients were used. A full list of the active ingredients can be found in Appendix B. The energy beverages were contained in unmarked, unidentifiable, sterile containers. The researcher required the subjects to sign that they had been correctly briefed before the test and that they would adhere to the rules and procedures of the test.

Instrument Pre Test

The researchers conducted a satisfactory pre test for all instruments utilized in the experiment. The pre test enabled the researchers to recommend whether the instruments met the needs of the experiment and to design a set of procedures for each scenario. The test results were monitored and approved by advising professors, who double-checked for accuracy and screened for unforeseen anomalies.

Subjects

For the purpose of this study, the experimental sample consisted of students from Embry-Riddle Aeronautical University, Daytona Beach, Florida Campus. The students in the sample all held a minimum of a FAA class II medical certificate and a certificated pilot's license with instrument rating.

The sample of students were self-selected as respondents to advertisements within Embry Riddle Aeronautical University. This method of self-selection had been identified as being appropriate, as the subjects have no influence on this type of study, providing they met the outlined requirements. There were 11 qualified students who volunteered, and they were tested over the course of eight sessions, which were completed over one week.

Sources of the Data

An initial set of data was collected from the pre-test survey. The survey data included questions on demographics and subjects' habits. The survey data was collected to enable the researcher to decide whether the subject qualified for testing. The survey questions are found in Appendix B.

Test data was obtained from the output files produced by the *Mentor* Advanced AATD. The AATD recorded multiple outputs; however, for the purpose of this experiment, the researcher collected data on deviation from glide slope (dots), deviation from localizer (feet MSL) and deviation from target speed (knots). Analysis was calculated based on the means of each variable.

Further data was collected for descriptive purposes from the subject's pulse beats-per-minute (BPM), and blood oxygen levels (SpO2%) . The subjects were asked to provide a pulse-oximeter reading before entering the HAL and upon exit from the HAL.

Instrument reliability. The instruments were selected to be accurate measures of the tested variables. However, there were limitations in HAL control software, as the altitude is accurate to within +/- 300 feet MSL (CAT, 2009). The typical figures relating to the most common pulse oximeter instruments are ± 2 BPM or ± 2% blood oxygen levels (Nonin, 2011). The *Mentor* AATD was rated for accuracy by the FAA and was regarded as an accurate representation of a true-to-life flight task (Frasca, 2011). The survey was utilized to validate the procedures and rules surrounding testing and to qualify/disqualify subjects, based on the predetermined rules.

Instrument validity. To maintain validity, all tests were administered in the same way, following the same time schedule. The instruments were calibrated before testing, and a pre test was conducted by the researchers. At all times, two or more researchers managed the proceedings by providing cross-checks. All subjects spent the same maximum amount of time in the HAL, as synchronized by all researchers. All subjects drank the same quantity of each of the beverages. The beverages were administered at exactly the same time before entering the HAL for all subjects in all tests. The pre test survey was completed as fairly as possible and required honesty from the subjects.

Treatment of the Data

Descriptive statistics. For the pre-test survey, Questions 1, 4, 6, 10, 12 and 14 were nominal data and were described by figures. Questions 5, 7 and 15 of the survey used the Likert scale and were regarded as interval data; therefore they were described in bar graphs. Questions 8, 9, 13, 16 and 17 were ordinal data and described by figures. Questions 2, 11 and 19 were interval data and were described in tables containing mean, standard deviation, minimum, maximum, and count. Questions 3, 18 and 20 required either a 100% answer or 0 answer and were described by statements.

The pulse-oximeter output variables were pulse rate (BPM) and oxygen saturation levels (SpO2%) and were regarded as ratio data which were described in tables containing the mean, standard deviation, minimum, maximum, and count.

Data outputs from the *Mentor* AATD were the variables: deviation from glide slope, deviation from localizer, and deviation from target speed for each subject and for each beverage. Deviations were ratio data and were described in tables containing mean, standard deviation, minimum, maximum, and count.

Hypothesis testing. The data from the *Mentor* AATD was checked at the source for errors. The data was manipulated into samples for each variable for each subject. The evaluated data were made of the previous two minutes leading up to decision height, for each of the variables and for each participant's three tests. The *Mentor* AATD produced one data output per second (Frasca, 2011). The variables were categorized by beverages 1, 2 and 3, and by approach plates 1, 2, and 3. These are summarized in Appendix E. The means were calculated for each variable for each category. A repeated-measures-ANOVA was calculated for each variable, analyzing each of the beverages, and each of the approach plates against each other to test for significance.

Pilot Study

The experiment was conducted as a pilot study and will enable further research to be completed in the HAL concerning this subject. This pilot study investigated the feasibility of conducting a future project with a larger population.

Chapter IV

Results

Descriptive Statistics – Pre-Test Questionnaire

Eleven students from Embry Riddle Aeronautical University were given a pre-test questionnaire before entering the HAL. Figure 1 describes the response to Question 1: Have you ever been in the HAL or other similar lab?

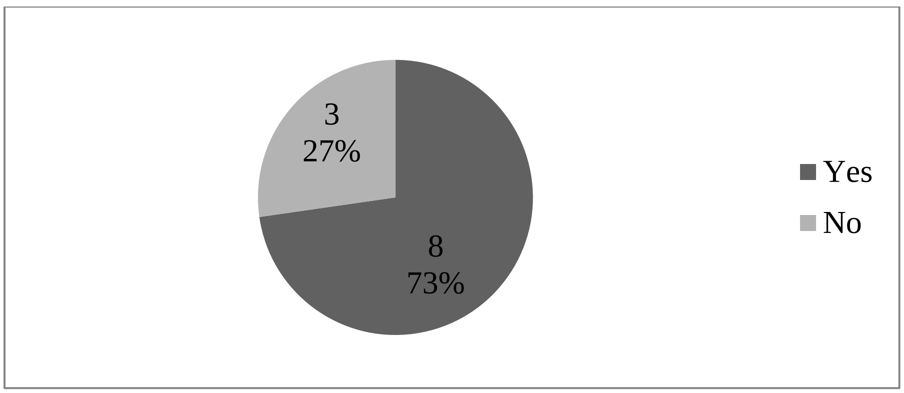

Figure 1. Question #1.

Table 2 describes the response to Question 2: How many times have you been in the Lab?

Table 2

Descriptive Statistics for Question 2

Mean	*SD*	Min	Max	*N*
2.2	1.3	0	3	11

Question 3: Are you a pilot? One-hundred percent answered yes, validating the requirement.

Figure 2 describes the response to Question 4: What is your highest pilot certification or rating? (PP = Private Pilot, COM = Commercial Pilot, CME = Commercial Multi Engine, CFI = Certified Flight Instructor)

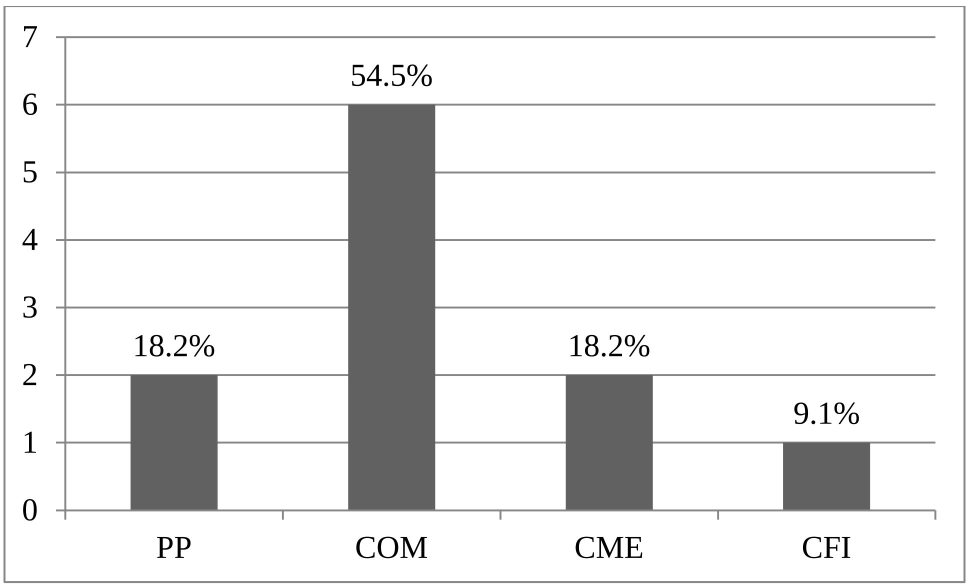

Figure 2. Question #4.

Figure 3 describes the response to Question 5: I am anxious about my HAL experience today.

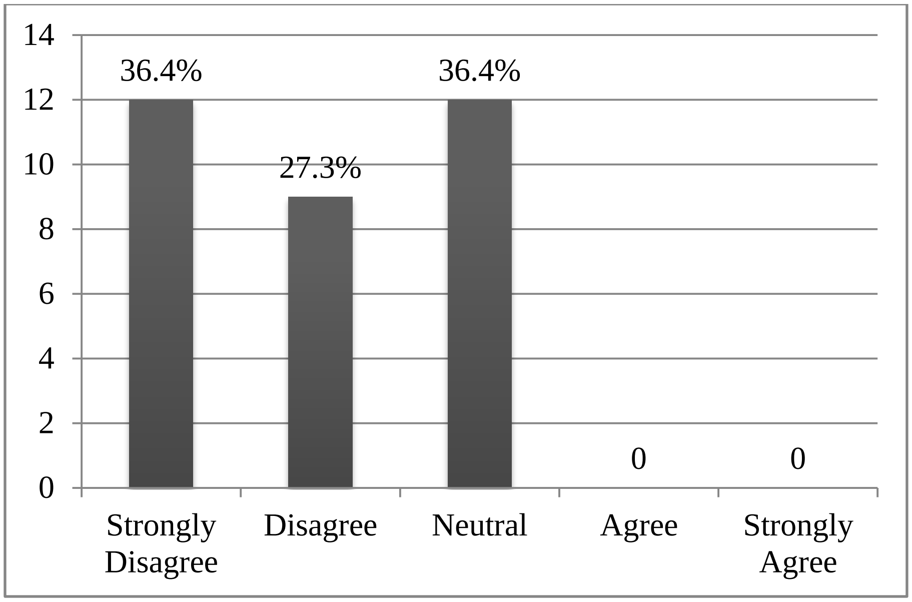

Figure 3. Question #5. *Note*. Each subject responded three separate times to this question.

Figure 4 describes the response to Question 6: I maintained a balanced diet within the last 24 hours

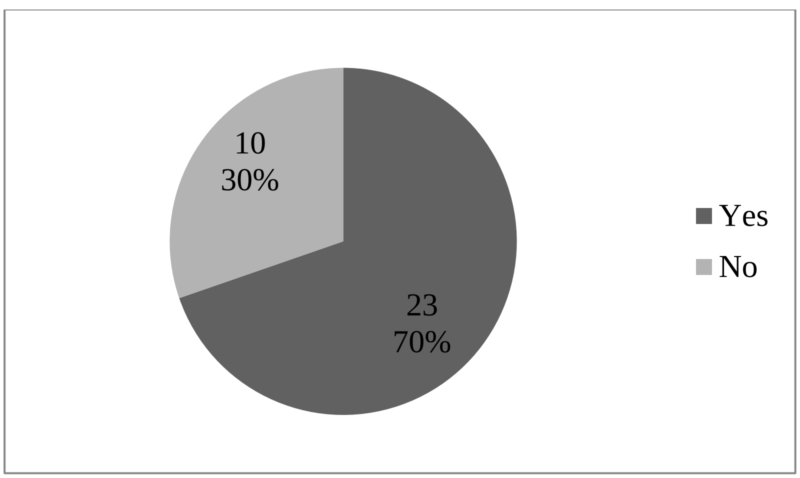

Figure 4. Question #6. *Note*. Each subject responded three separate times to this question.

Figure 5 describes the response to Question 7: I typically drink caffeine-based products and/or energy drinks

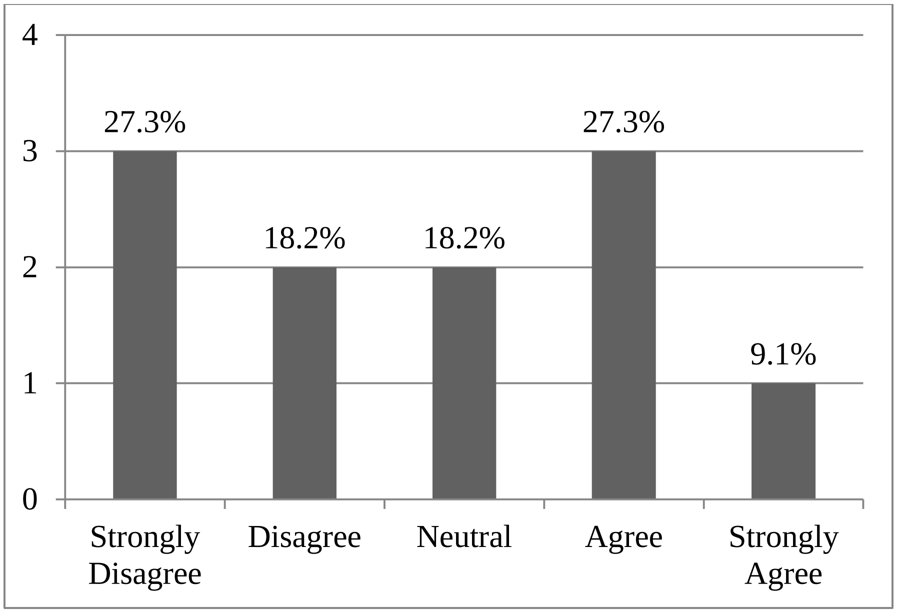

Figure 5. Question #7.

Figure 6 describes the response to Question 8: When was your last caffeine-based product and/or energy drink?

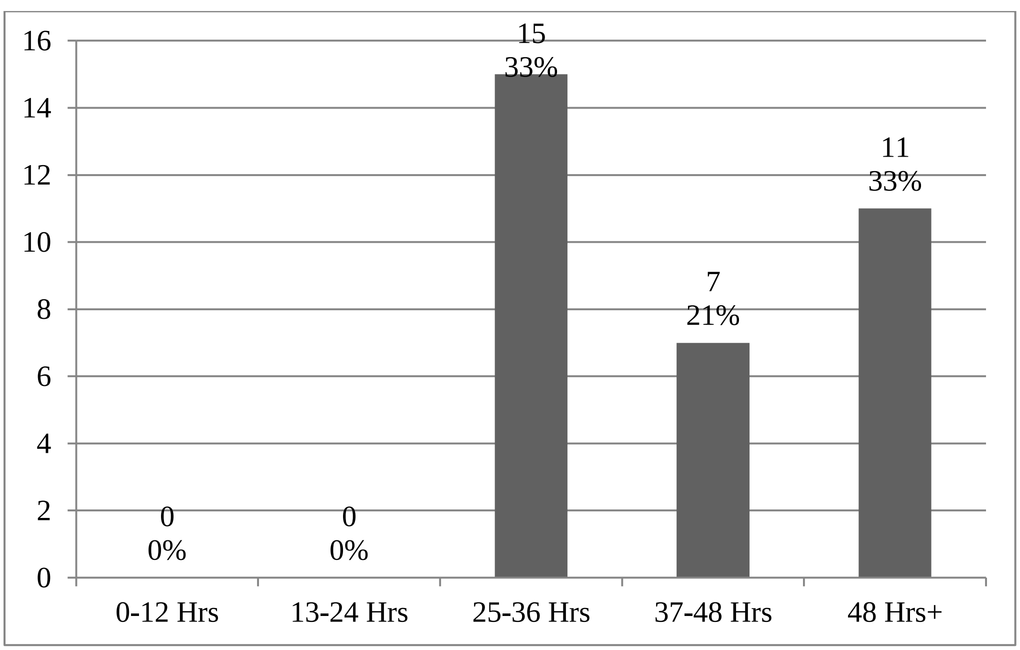

Figure 6. Question #8. *Note*. Each subject responded three separate times to this question.

Figure 7 describes the response to Question 9: When was your last meal?

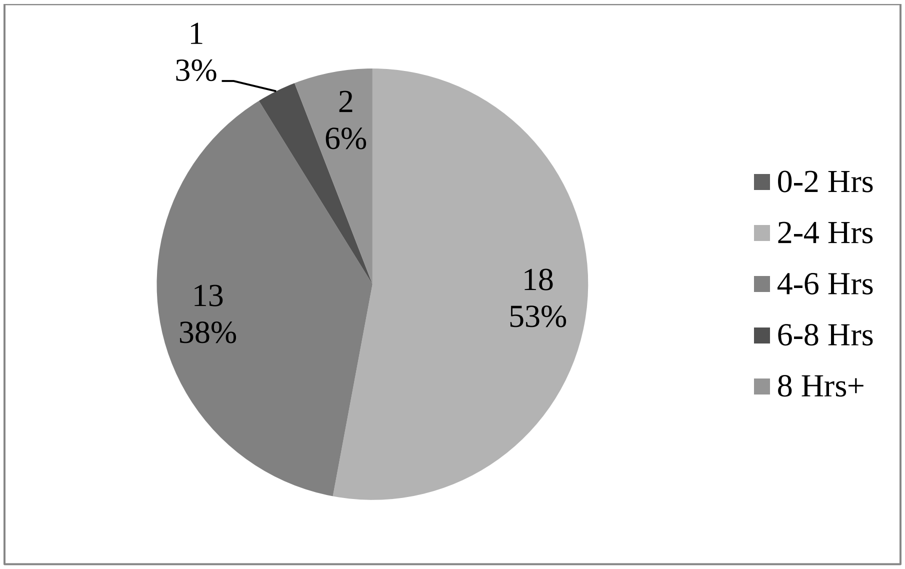

Figure 7. Question #9. *Note*. Each subject responded three separate times to this question.

Figure 8 describes the response to Question 10: I got 8 hours or more of sleep last night.

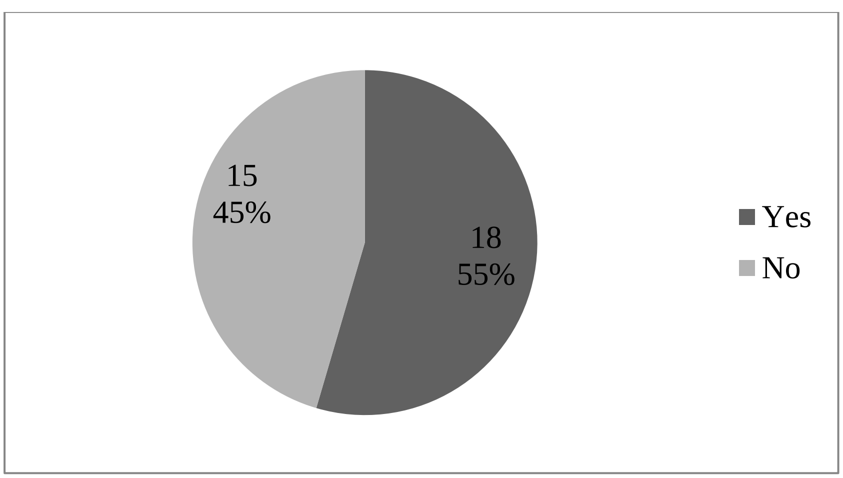

Figure 8. Question #10. *Note*. Each subject responded three separate times to this question.

Table 3 describes the response to Question 11: Within the last 7 days, how many nights did you sleep for 8 hours or more?

Table 3

Descriptive Statistics for Question 11

Mean	*SD*	Min	Max	*N*
4.1	2.9	0	7	33

Note: Each subject responded three separate times to this question.

Figure 9 describes the response to Question 12: I typically get 8 hours or more of sleep nightly.

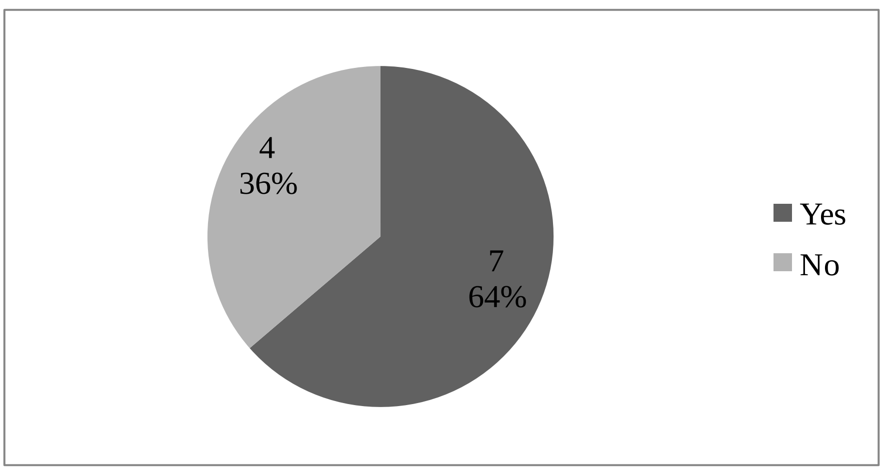

Figure 9. Question #12.

Figure 10 describes the response to Question 13: How much sleep did you get within the last 24 hours?

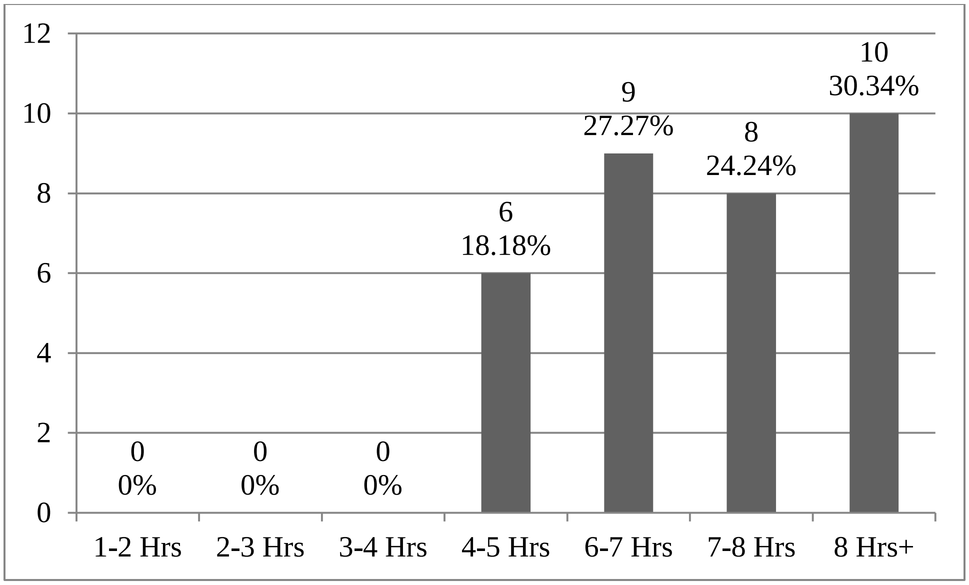

Figure 10. Question #13. *Note*. Each subject responded three separate times to this question.

Figure 11 describes the response to Question 14: I exercised 30 minutes or more within the last 24 hours.

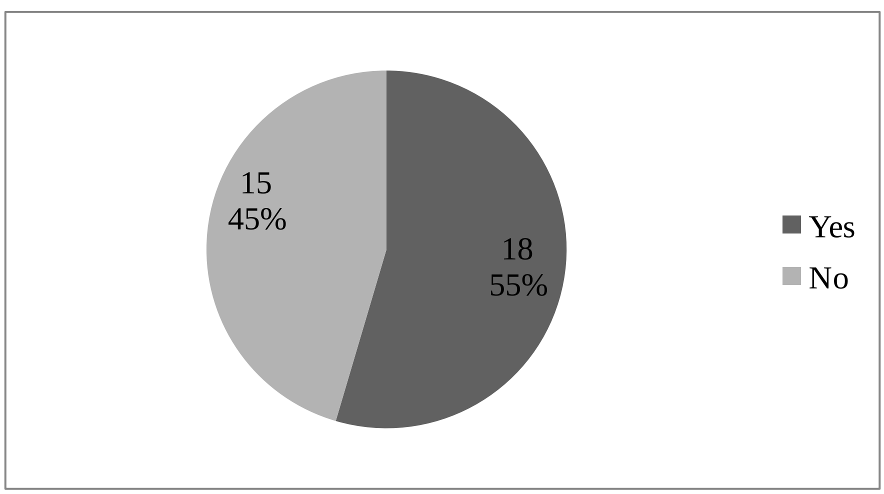

Figure 11. Question #14. *Note.* Each subject responded three separate times to this question.

Figure 12 describes the response to Question 15: I typically exercise for at least 30 minutes, three separate times, weekly.

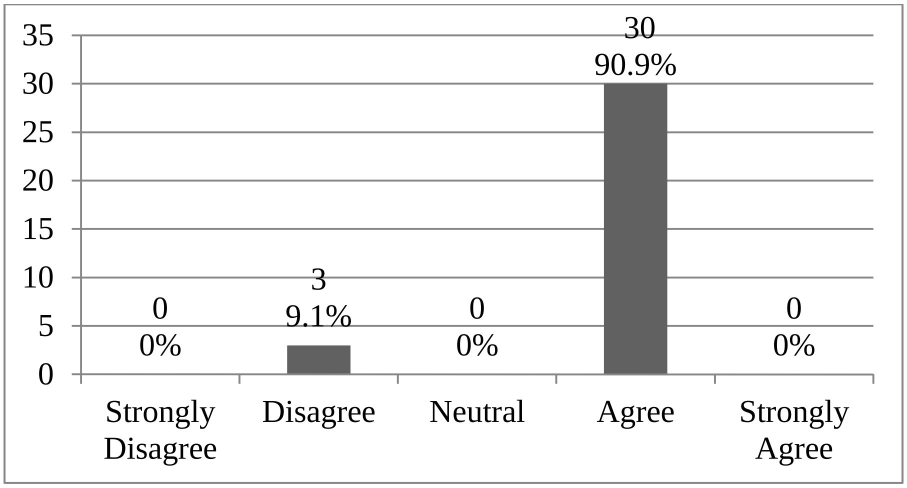

Figure 12. Question #15. *Note.* Each subject responded three separate times to this question.

Figure 13 describes the response to Question 16: When did you last exercise?

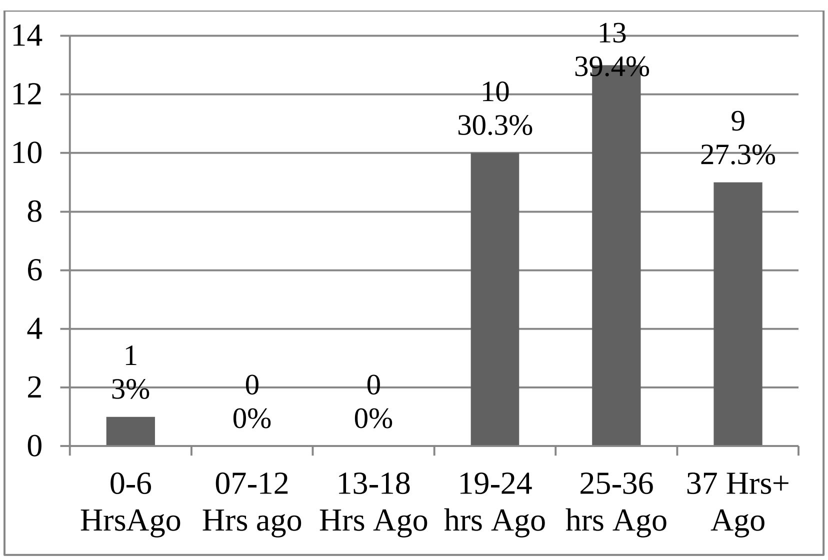

Figure 13. Question #16. *Note.* Each subject responded three separate times to this question.

Figure 14 describes the response to Question 17: How long did you last exercise for?

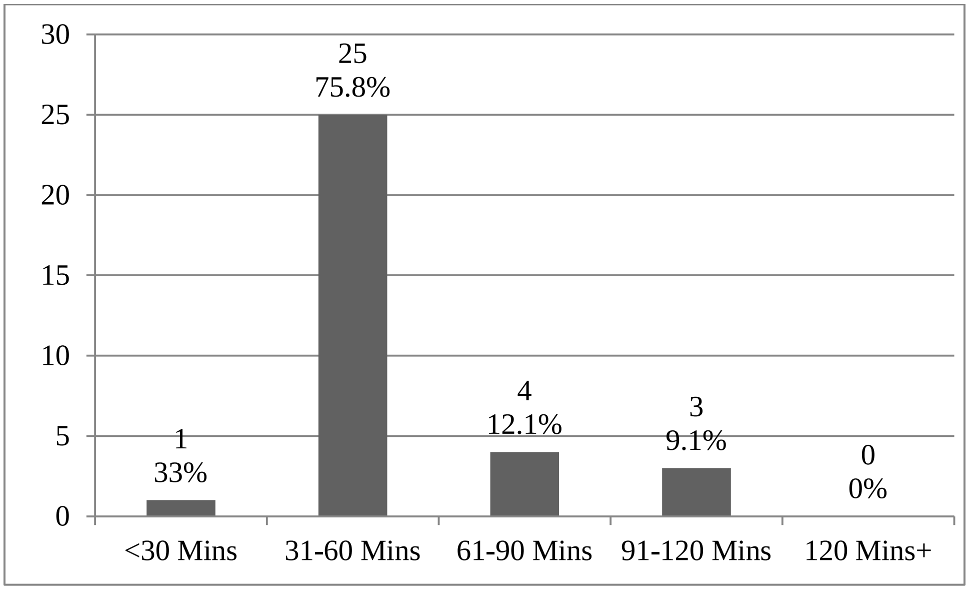

Figure 14. Question #17. *Note.* Each subject responded three separate times to this question.

For Question 18: How many alcoholic drinks have you consumed within 24 hours? All subjects answered zero, validating the requirement.

Table 4 describes the response to Question 19: How many alcoholic drinks have you consumed within the last 7 days?

Table 4

Descriptive Statistics for Question 19

Mean	*SD*	Min	Max	*N*
3.4	4.6	0	14	33

Note: each subject responded three separate times to this question.

For Question 20: Do you smoke tobacco? One-hundred percent of the participants responded "no," thus validating the requirement.

Descriptive Statistics – Pulse Oximeter Readings

Eleven students from Embry-Riddle Aeronautical University gave pre-test and post-test Pulse-Oximeter readings that were recorded before entering the HAL and upon leaving the HAL. Table 5 depicts the Pulse-BPM results.

Table 5

Descriptive Statistics for Pre/Post-Test BPM Recordings

		Mean	*SD*	Max	Min	*N*
Red Bull®	BPM Before Test	78.0	19.1	113	53	11
	BPM After Test	93.4	18.2	125	69	11
	BPM Change	15.4	19.3	61	-6	11
	Test Duration (Min)	22.2	2.8	27	19	11
Monster®	BPM Before Test	91.2	18.7	118	64	11
	BPM After Test	106.2	10.3	129	94	11
	BPM Change	15.0	13.5	34	-10	11
	Test Duration (Min)	19.4	2.1	24	15	11
Placebo	BPM Before Test	75.9	11.8	100	61	11
	BPM After Test	99.3	15.2	118	78	11
	BPM Change	23.4	14.0	52	0	11
	Test Duration (Min)	19.2	2.5	25	15	11

Table 6 depicts the Oximeter - SpO2 results.

Table 6

Descriptive Statistics for Pre/Post-Test %SpO2 Recordings

		Mean	*SD*	Max	Min	*N*
Red Bull®	%SpO2 Before Test	98.64	1.03	100	97	11
	%SpO2 After Test	87.00	3.52	94	82	11
	%SpO2 Change	- 11.64	3.47	-6	-17	11
	Test Duration (Min)	22.18	2.79	27	19	11
Monster®	%SpO2 Before Test	98.73	1.19	100	97	11
	%SpO2 Test	89.00	5.06	98	81	11
	%SpO2 Change	- 9.73	4.58	-1	-16	11
	Test Duration (Min)	19.36	2.11	24	15	11
Placebo	%SpO2 Before Test	97.91	0.83	99	96	11
	%SpO2 After Test	86.36	4.65	93	79	11
	%SpO2 Change	- 11.55	4.76	-5	-19	11
	Test Duration (Min)	19.18	2.52	25	15	11

Descriptive Statistics – AATD Performance Output

Eleven students from Embry Riddle Aeronautical University completed three simulated flight tasks within the HAL, using the Frasca International *Mentor* AATD. The flight tasks were simulated Instrument landing System (ILS) approaches at Gainesville, Jacksonville or St. Augustine. The researcher derived three test variables from core outputs of the AATD: (a) lateral deviations from localizer in dots (one dot equals 2 degrees) (FAA, 2011), (b) vertical deviations from Glide Slope (GS) in feet MSL, and (c) indicated airspeed (IAS) deviations from target speed of 100 knots. Table 7 describes the results.

Table 7

Descriptive Statistics Displaying AATD Outputs for Gainesville, Jacksonville, or St. Augustine

		Mean	*SD*	Min	Max	*N*
Gainesville	Localizer Deviations	0.68	0.47	0.20	1.67	11
	GS Deviations	27.22	19.50	11.59	71.87	11
	IAS Deviations	2.46	1.08	1.32	4.64	11
Jacksonville	Localizer Deviations	0.50	0.29	0.18	1.17	11
	GS Deviations	53.35	104.67	8.06	366.44	11
	IAS Deviations	3.61	4.15	0.74	15.34	11
St Augustine	Localizer Deviations	0.53	0.33	0.18	1.02	11
	GS Deviations	56.96	104.18	8.99	366.44	11
	IAS Deviations	2.16	1.12	0.86	4.24	11

Eleven students from Embry Riddle Aeronautical University completed three simulated flight tasks within the HAL, using the Frasca International *Mento*r AATD. The flight tasks were completed after consuming Red Bull®, Monster®, or a placebo beverage. The researcher derived three test variables from core outputs of the AATD: Lateral deviations from localizer in dots (one dot equals 2 degrees) (FAA, 2011); vertical deviations from (GS) in feet MSL; and indicated airspeed (IAS) deviations from target speed of 100 knots. Table 8 describes the results.

Table 8

Descriptive Statistics Displaying AATD Outputs for Red Bull®, Monster®, or a Placebo

		Mean	*SD*	Min	Max	*N*
Red Bull®	Localizer Deviations	0.69	0.45	0.28	1.67	11
	GS Deviations	92.49	136.45	13.70	366.44	11
	IAS Deviations	3.43	4.05	1.00	15.34	11
Monster®	Localizer Deviations	0.50	0.27	0.18	1.02	11
	GS Deviations	24.49	18.51	8.99	72.34	11
	IAS Deviations	2.61	1.10	1.02	4.44	11
Placebo	Localizer Deviations	0.52	0.36	0.19	1.17	11
	GS Deviations	20.55	14.43	8.06	52.12	11
	IAS Deviations	2.19	1.56	0.74	5.47	11

Hypothesis Testing

Approach plate related to simulated flight task performance. A Repeated-Measures-ANOVA was calculated to test the null hypothesis – There will be no differences in simulated flight task performance variables (Localizer deviation, Glide-Slope deviation, and Indicated Airspeed deviation) among the approaches selected by random design at a constant 14,000 feet MSL. Tables 9, 10, and 11 show the results. For all three measures of performance in the AATD, there were no differences for the randomized approaches. Therefore, the repeated-measures ANOVA failed to reject the null hypothesis.

Table 9

Repeated-Measures ANOVA Comparing Localizer Deviation Between Approaches

	Mean	Std. Deviation	*N*
Localizer Deviation Gainesville	.682	.471	11
Localizer Deviation Jacksonville	.502	.293	11
Localizer Deviation St Augustine	.529	.327	11

Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Localizer Deviation	Pillai's Trace	.190	1.055[a]	2.000	9.000	.388	.190
	Wilks' Lambda	.810	1.055[a]	2.000	9.000	.388	.190
	Hotelling's Trace	.234	1.055[a]	2.000	9.000	.388	.190
	Roy's Largest Root	.234	1.055[a]	2.000	9.000	.388	.190

a. Exact statistic

Table 10

Repeated-Measures ANOVA Comparing Glide-Slope Deviation Between Approaches

	Mean	Std. Deviation	*N*
Glide-Slope Deviation Gainesville	27.217	19.496	11
Glide-Slope Deviation Jacksonville	53.354	104.668	11
Glide-Slope Deviation St Augustine	56.964	104.183	11

Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Glide-Slope Deviations	Pillai's Trace	.172	.935[a]	2.000	9.000	.427	.172
	Wilks' Lambda	.828	.935[a]	2.000	9.000	.427	.172
	Hotelling's Trace	.208	.935[a]	2.000	9.000	.427	.172
	Roy's Largest Root	.208	.935[a]	2.000	9.000	.427	.172

a. Exact statistic

Table 11

Repeated-Measures ANOVA Comparing Indicated Airspeed Deviation Between Approaches

	Mean	Std. Deviation	*N*
Indicated Airspeed Deviations Gainesville	2.460	1.076	11
Indicated Airspeed Deviations Jacksonville	3.610	4.150	11
Indicated Airspeed Deviations St Augustine	2.169	1.120	11

Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Indicated Airspeed Deviations	Pillai's Trace	0.25	1.497[a]	2.00	9.00	0.27	0.25
	Wilks' Lambda	0.75	1.497[a]	2.00	9.00	0.27	0.25
	Hotelling's Trace	0.33	1.497[a]	2.00	9.00	0.27	0.25
	Roy's Largest Root	0.33	1.497[a]	2.00	9.00	0.27	0.25

a. Exact statistic

Energy beverage related to simulated flight task performance. A Repeated-Measures-ANOVA was calculated to test the null hypothesis – There will be no differences in simulated flight task performance variables (Localizer deviation, Glide-Slope deviation, and Indicated Airspeed deviation) among the energy beverages selected by specified design at a constant 14,000 feet MSL. Tables 12, 13, and 14 show the results. For all three measures of performance in the AATD, there were no differences for the specified beverage. Therefore, the repeated-measures-ANOVA failed to reject the null hypothesis.

Table 12

Repeated-Measures ANOVA Comparing Localizer Deviation Between Beverages

		Mean		Std. Deviation		*N*
Localizer Deviation Red Bull®		.692		.452		11
Localizer Deviation Monster®		.504		.274		11
Localizer Deviation Placebo		.517		.3622		11
Effect	**Value**	***F***	**Hypothesis *df***	**Error *df***	**Sig.**	**Partial Eta Squared**
Localizer Deviation — Pillai's Trace	.190	1.056[a]	2.000	9.000	.387	.190
Wilks' Lambda	.810	1.056[a]	2.000	9.000	.387	.190
Hotelling's Trace	.235	1.056[a]	2.000	9.000	.387	.190
Roy's Largest Root	.235	1.056[a]	2.000	9.000	.387	.190

a. Exact statistic

Table 13

Repeated-Measures-ANOVA Comparing Glide-Slope Deviation Between Beverages

		Mean		Std. Deviation		*N*
Glide-Slope Deviation Red Bull®		92.494		136.453		11
Glide-Slope Deviation Monster®		24.487		18.512		11
Glide-Slope Deviation Placebo		20.554		14.426		11
Effect	**Value**	***F***	**Hypothesis *df***	**Error *df***	**Sig.**	**Partial Eta Squared**
Glide-Slope Deviations — Pillai's Trace	.371	2.659[a]	2.000	9.000	.124	.371
Wilks' Lambda	.629	2.659[a]	2.000	9.000	.124	.371
Hotelling's Trace	.591	2.659[a]	2.000	9.000	.124	.371
Roy's Largest Root	.591	2.659[a]	2.000	9.000	.124	.371

a. Exact statistic

Table 14

Repeated-Measures ANOVA Comparing Indicated Airspeed Deviation Between Beverages

	Mean	Std. Deviation	*N*
Indicated Airspeed Deviation Red Bull®	3.429	4.048	11
Indicated Airspeed Deviation Monster®	2.609	1.105	11
Indicated Airspeed Deviation Placebo	2.191	1.564	11

Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Indicated Airspeed Deviations	Pillai's Trace	.117	.597[a]	2.000	9.000	.571	.117
	Wilks' Lambda	.883	.597[a]	2.000	9.000	.571	.117
	Hotelling's Trace	.133	.597[a]	2.000	9.000	.571	.117
	Roy's Largest Root	.133	.597[a]	2.000	9.000	.571	.117

a. Exact statistic

Chapter V

Discussion, Conclusions, and Recommendations

Discussion

This study was designed to see if there was a gain in performance by a set of subjects, based on the *Mentor* AATD output variables (lateral deviation, vertical deviation, and airspeed deviation), during periods of simulated low-altitude hypoxia, when subjects consumed different energy beverages, including a placebo. The study-design was developed to provide an analytical pilot study that could supply evidence for a safety recommendation to pilots who may be exposed to conditions conducive of low-altitude hypoxia. The population consisted of 11 male pilots who had a minimum of a private pilot's license with an instrument rating, and at least a second-class medical certificate.

Localizer deviations. A repeated-measures-ANOVA was calculated to evaluate effects of the energy beverages and the placebo beverage on subjects' *Mentor* AATD performance outputs. The significance for localizer deviations among the averages of the subjects revealed (p = .387), based on Pillai's Trace, as calculated in the repeated-measures-ANOVA. The mean following consumption of Red Bull® was .692 with a standard deviation of .452, which was the greatest value. The second ranked mean value was following consumption of the placebo with .517, and a standard deviation of .3622. Consumption of the Monster® produced the lowest mean for lateral deviation with .504, and a standard deviation of .274.

The researcher suggests that the small significance may be explained by Type 2 error because of the small number of subjects. In addition, the researcher suggests that practice effects may have affected the results. Specifically, an explanation for Red Bull® performing worst for the variable (lateral deviation) was that Red Bull® was the first beverage all subjects consumed. Therefore, it was the first attempt for all subjects to use the *Mentor* AATD. The designed order of beverages was Red Bull®, Monster®, and then placebo. The mean times per test indicate that subjects performed the task quicker as they gained experience in the AATD. Red Bull®, the first test, had a mean test time of 22 minutes and 18 seconds; Monster® had a mean test time of 19 minutes and 36 seconds; and the placebo beverage had a mean test time of 19 minutes and 18 seconds. As the times decreased with the number of tests completed, the researcher suggests that the subjects improved in proficiency on the *Mentor* AATD, which may have inadvertently skewed results for the placebo. In addition, the subjects spent the longest time in the HAL on their first test, which was Red Bull®; therefore, the subjects had a longer exposure to the hypoxic environment, which possibly attributed to decreased performance. It should be noted that the standard deviation for the placebo was the greatest, followed by Red Bull® and then Monster®. As the placebo beverage had a larger standard deviation, the researcher concluded that some subjects performed worse upon consuming the placebo beverage, based on the *Mentor* AATD output of lateral deviation, and compared with the other beverages.

Glide-Slope deviations. The performance variable, GS deviations, had a significance of (p =.124) based on Pillai's Trace, as calculated in the repeated-measures-ANOVA. The p-value was not statistically significant; however, it was smaller than that seen with the performance output (lateral deviation) (p = .387).

The mean value for Red Bull® was greatest with a value of 92.494 and a standard deviation of 136.453. The mean value for Monster® was 24.487 with a standard deviation of 18.512. The placebo had a mean of 20.554 and a standard deviation of 14.426.

The *Mentor* AATD output performance indicator (GS deviation) showed that the subjects performed best following the consumption of the placebo beverage. However, the researcher concluded that the results may be conflicted, as the subjects spent the shortest time in the HAL when completing the placebo simulated test, and would have been least affected by the reduced oxygen environment. In addition, the subjects were most practiced on the third run, which may explain why the gap between the means of the Monster® and the placebo are small compared to the gap between Red Bull® and Monster®. In addition, the researcher suggests that the small significance may be explained by Type 2 error, because of the small number of subjects.

Indicated airspeed deviations. The performance variable, indicated airspeed deviations, showed the least significance (p =.571) based on Pillai's Trace, as calculated in the repeated-measures-ANOVA**.** There were no significant differences among the three beverages; however, trials with Red Bull® continued to have higher deviations. The mean value for Red Bull® was again greatest with a value of 3.429 and a standard deviation of 4.048. The mean value for Monster® was 2.609 with a standard deviation of 1.105. The placebo had a mean of 2.191 and a standard deviation of 1.564.

The *Mentor* AATD output performance indicator (indicated airspeed deviation) again showed that the subjects performed best following the consumption of the placebo beverage. The lack of significance recorded is consistent with Type 2 error, which is common with a small test population. A pilot study is by design a method of evaluating the possibility for further study through preliminary testing with a small population. The subjects performed worst upon consumption of a Red Bull®. There was again a larger gap between the performances recorded from the subjects' first test (Red Bull®), compared to the subjects' second test (Monster®). The gap recorded in performance between test two (Monster®), and test three (placebo) was minimal.

Pulse-Oximeter. The test data related to the pulse-oximeter was not valid for a statistical analysis, as the readings were taken outside of the HAL. The readings were taken outside of the HAL because, if the subjects had been aware of their %SpO2 readings during testing, they could have determined the simulated altitude. The readings were taken immediately before the subjects entered the HAL and immediately upon exiting the HAL; and as such, the descriptive statistics highlight some interesting observations.

Comparing the mean changes in the subjects' heart rates upon consumption of each beverage, some conclusions can be drawn on the physiological effects of the beverages on the subjects. The mean increase in heart rate following the consumption of Red Bull® was 15.4 BPM; the mean increase in heart rate following the consumption of Monster® was 15 BPM; and the mean increase in heart rate following the consumption of the placebo was 19.2 BPM. Therefore, the average subject's heart-rate increase was smallest following the consumption of Monster®, second was Red Bull®, and the greatest increase followed the consumption of a placebo. An explanation for this may be attributed to the increasing levels of Taurine found in the energy beverages compared to the placebo. Taurine has been shown to stabilize a human’s heartbeat when exposed to elevated levels of stress (Kotke & Gehrke, 2008).

Comparing the mean changes in the subjects' blood-oxygen levels upon consumption of each beverage; further conclusions can be drawn. The mean blood-oxygen saturation change for Red Bull® was -11.64 %SpO2, the mean blood-oxygen saturation change for Monster® was -9.73 %SpO2, and the mean blood-oxygen saturation change for the placebo was -11.55 %SpO2. Therefore, the average change in the subjects' blood-oxygen saturation was smaller upon consuming the Monster® energy beverage. The placebo and the Red Bull® beverages showed close results, with the placebo having the least saturation. However, it is important to note that the mean time in the HAL during Red Bull® testing was exactly three minutes longer than that of the placebo. Therefore, the researcher concluded that the saturation might have been smaller upon consumption of the Red Bull® if the exposure times were equal.

Conclusions

The analyses of the hypothesis were not significant; however, the descriptive results were encouraging. The researcher concluded that there were non-significant differences among the performance indicators upon consumption of the energy beverages compared to the consumption of the placebo.

The researcher concluded that changes in performance despite being statistically insignificant might be attributed to an improved concentration and a physiological change in the body’s ability to absorb oxygen from the air due to the large dose of active ingredients contained within the beverages (Kotke & Gehrke, 2008). The caffeine contained within the energy beverages is a central nervous system stimulant and is designed to improve reaction times and mental function (Reissig et al., 2008).

The enhanced concentration attributed to the energy beverages might have produced the increased performance noted in the results. In addition, the high doses of Taurine found in both energy beverages might have slowed the subjects' heart rates compared to the placebo (Amendola et al., 2004). An increased heart rate is a symptom of low altitude hypoxia, as noted by Darwish (2003).

The researcher concluded that the cocktail of B-vitamins found in the energy beverages might have marginally improved the body's efficiency in absorbing oxygen from the reduced oxygen environment as reported by American Dietetic Association (2000). When Taurine and large doses of B-vitamins are combined, the body stabilizes and improves in efficiency when subjected to increased mental and physical stress. This is a benefit when the body is in need of more oxygen (Amendola et al., 2004; Kotke & Gehrke, 2008; Reissig et al., 2008).

The researcher concluded that the Monster® energy beverage had the most potent effects, as it has twice the active ingredients found in Red Bull® (American Dietetic Association, 2000). The evidence supporting this statement can be seen in the results from the repeated-measures-ANOVA for the performance indicator, Localizer Deviations. The descriptive statistics from the blood-oxygen-saturation recordings support this statement.

Only a small number of the aviation accidents being reported annually are attributed to low-altitude hypoxia. However, the potential for pilots to experience low-altitude hypoxia is a credible danger. The researcher concluded that there was some supporting evidence that would support conducting further research on this subject, with an aim of making a safety recommendation to pilots. The researcher concluded that this pilot study was affected by Type 2 error where the sample size was too small and results were likely impacted by practice effects.

Recommendations

The results obtained from the *Mentor* AATD and the Pulse-Oximeter are consistent with a pilot study and have produced encouraging signs for further research. Future research should have a larger population. By testing a minimum of 33 subjects, the results would not be subject to Type 2 error, as in this study. Typically, a minimum of 33 subjects would have been required to achieve a 0.05 effect size.

The researcher recommends that the design should randomize the energy beverages as well as the approach plates. By randomizing the energy beverages, the results would not show indications of a practice effect from the first beverage to the last, with respect to the subject's proficiency on the *Mentor* AATD. There was evidence supporting improvement from the first beverage to the second beverage. In addition, there was a difference in the time of exposure from the first test to the last, due to practice effects.

The researcher additionally recommends that the subjects complete several pre-test simulation approaches to enable them to have enough time to be proficient in the use of the *Mentor* AATD, thus eliminating the differences in exposure time. In addition, there was evidence from questionnaire question (What is your highest pilot qualification or rating?) that there were pilots with varied levels of experience. Further research should group subjects based on experience.

The researcher observed that the subjects spent different times consuming the beverages. In future research the test schedule should be designed to begin the test from the point of consumption and not from the time the beverage was provided.

The researcher recommends that the pulse-oximeter readings should be used for analysis. The pulse-oximeter could include a wireless sensor that would send the readings outside of the HAL, so the subjects are never aware of the readings. The researcher also suggests that a greater variety of test variables be analyzed from the *Mentor* AATD data outputs.

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Appendix A

Permission to Conduct Research

Dear Cass Howell & Daniel Bull,

The Chair of the IRB has reviewed the revised protocol application for the project titled, ***"Effects of Energy Beverages in Counteracting the Symptoms of Mild Hypoxia at General Aviation Altitudes"*** to see that it met with all the requirements as written in the Determination Form as was established at the full IRB Committee meeting. All of the outstanding issues have been addressed and clearly stated in the application and Consent Form.

You may begin your data collection. Attached is the Revised Determination Form for your records. Best of luck in your endeavors.

Teri Vigneau (va new), CRA, MPA

Human Protections Administrator

Pre-Award Manager

Sponsored Programs

(386) 226-717

Appendix B

Pre Test Survey

Pre-test Survey

Dear participant please complete the following pre-test survey. It is compulsory, and the reliability of the results is dependent on the accuracy of the answers provided. The questions are designed to ensure this test is completed as safely as possible. Please circle the most appropriate option, to the best of your ability even if it means you become exempt from testing. Another test session can be arranged. This questionnaire studies whether daily habits influence hypoxic reactions during a HAL exposure and all answers will remain confidential, Circle or fill in the answers as appropriate. Questions 1,2,3,4,7,12,15 and 20 are only required on the first test session ~Thank you.

Date:__________________ **Time:** ______________

HAL Experience:

1. Have you ever been in the HAL or other similar lab?
(Circle one) Yes No

2. How many times have you been in the Lab? 0 1 2 3 4

3. Are you a pilot?
(Circle one) Yes No

4. What is your highest pilot certification or rating?
(Circle one) PP COM CME CFI

5. I am anxious about my HAL experience today.
(Circle one) Strongly Disagree Disagree Neutral Agree Strongly Agree

Eating Habits: *A balanced diet is 2,000 calories a day from eight servings of grains, five servings of vegetables and fruits, three servings of milk or dairy products, two or fewer servings of meat and beans, and three servings of healthy oils (US Department of Agriculture).*

6. I maintained a balanced diet within the last 24 hours.
(Circle one) Yes No

7. I typically drink caffeine-based products and/or energy drinks
(Circle one) Strongly Disagree Disagree Neutral Agree Strongly Agree

8. When was your last caffeine-based product and/or energy drink *
(Circle one) 0-12 Hrs 13-24 Hrs 25-36 Hrs 37-48 Hrs 48 Hrs+

*** Note: If you have consumed a caffeine-based product and/or energy drink within 24 hours prior to testing, you cannot complete the test today**

9. When was your last meal?**
(Circle one) 0-2 Hrs 2-4 Hrs 4-6 Hrs 6-8 Hrs 8 Hrs+

****Note: If you have eaten within the past 2 hours, you cannot complete the test today**

Sleeping Habits:

10. I got 8 hours or more of sleep last night.
(Circle one) Yes No

11. Within the last 7 days, how many nights did you sleep for 8 hours or more?
(Circle one) 0 1 2 3 4 5 6 7

12. I typically get 8 hours or more of sleep nightly.
(Circle one) Yes No

13. How much sleep did you get within the last 24 hours?
(Circle one) 1-2 Hrs 2-3 Hrs 3-4 Hrs 4-5 Hrs 6-7 Hrs 7-8 Hrs 8 Hrs+

Exercise Habits:
14. I exercised 30 minutes or more within the last 24 hours. (Circle one) Yes No

15. I typically exercise for at least 30 minutes, three separate times, weekly.
(Circle one) Strongly Disagree Disagree Neutral Agree Strongly Agree

16. When did you last exercise?
(Circle one) 0-6 Hrs 07-12 Hrs 13-18 Hrs 19-24 hrs 25-36 hrs 37 Hrs+

17. How long did you last exercise for?
(Circle one) <30 Mins 31-60 Mins 61-90 Mins 91-120 Mins 120 Mins+

Drinking Habits: *An alcoholic drink is defined as a 12-ounce beer, 8-ounces of malt liquor, 5-ounces of wine, or a 1.5-ounce "shot." (US Department of Agriculture and Health)*

18. How many alcoholic drinks have you consumed within 24 hours?(Circle one)

0	1	2	3	4	5	6	7	8	9	10	10+

19. How many alcoholic drinks have you consumed within the last 7 days? (Circle one)

0	1	2	3	4	5	6	7	8	9	10	10+

*****Note: If you have consumed an alcoholic beverage within the last 24 hours, you cannot complete the test today**

Smoking Habits:

20. Do you smoke tobacco ****
(Circle one) Yes No

****** Note: If you smoke tobacco, you cannot complete this study**

I ……………………………… declare that the answers given are 100% accurate to the best of my knowledge, and I understand that the questionnaire has been designed to qualify or eliminate me from completing the study for the protection of my own safety.

Signed …………………………………

This concludes the questionnaire. Thank you for your time!

Appendix C

HAL Medical Screening and Release Forms

High Altitude Normobaric Lab
Medical Screening Checklist

Participation in the High Altitude Lab (HAL) is limited to ERAU faculty/ students who are:

1. At least 18 years of age, sophomore standing
2. Are enrolled in or have completed AS 357 Flight Physiology
3. Hold a pilot license with an instrument rating and at least a 2nd class FAA medical certificate or equivalent.
4. Have **no** known allergies or sensitivities to the ingredients identified in the list below

Acacia	Milk Thistle extract
Ascorbic Acid	Niacinamide
Aspartame	Pannax ginseng extract
Biloba	Pantothenate
Benzoate	Pantothenic Acid
Berry Juice	Phosphorus
Fruit Juice	Potassium
Caffeine	Pyridoxine
Calcium	Riboflavin
Camitne	Sodium
Camitne Fumarate	Sodium Citrate
D-ribose	Sucrose
Ginkgo Biloba leaf extract	Taurine
Ginseng	Vitamin A
Glucose	Vitamin B2
Glucuronolactone	Vitamin B3
Glycerol Ester of wood rosin	Vitamin B5
Grape seed extract	Vitamin B6
Guarana extract	Vitamin B12
Guarana seed	Vitamin C
Inositol	Vitamin D
L-Arginine	Vitamin E
L-Carnitine	Vitamin K
Maltodextrin	Yerba mate leaf extract

Restrictions: Participation in an altitude chamber flight will not be permitted if the applicant

1. Has a disqualifying beard (Beards are permitted if the individual can form an airtight oxygen mask seal.)
2. Has donated one unit (500 ml) of blood within 24 hours of the scheduled training
3. Is under the influence of alcohol, sedating or psychotrophic drugs, or has consumed any of the pre-mentioned within 24 hours prior to the test session.
4. Has any known allergies or sensitivities to the ingredients identified in the beverages required to be consumed
5. Smokes Tobacco

6. Has any known sensitivities to being subjected to a mildly hypoxic environment
7. Has eaten within two hours prior to arriving for the test session
8. Has consumed a coffee or energy based product within 24 hours prior to arriving for the test session

Safety Considerations

Following participation in a high altitude lab flight, the student should not fly solo or as a primary crewmember for a period of 12 hours.
The use of Chap Stick®, lip-gloss, oil or Vaseline® based make-up is not permitted in the lab while wearing oxygen masks.

Medical Screening:

For health and safety reasons, you must notify an instructor if you are currently experiencing any of the symptoms or conditions below:

- _______ Dizziness, fainting spells, unconsciousness or seizures
- _______ Eye or vision trouble (except corrective lens)
- _______ Heart or vascular trouble, or anemia
- _______ Upper respiratory infection, asthma or bronchitis
- _______ Chest pain or shortness of breath
- _______ Diabetes
- _______ Medications not approved for flight
- _______ Recent surgery
- _______ Pregnancy or you have other health concerns

Although unlikely, in some subjects symptoms relating to being in a low oxygen environment may include, but not be limited to dizziness, nausea, rapid breathing, visual impairment, mental confusion and poor coordination. Some headaches or nausea may also occur after the normobaric experience any time above sea level oxygen content. If this occurs, you **must** tell the instructor/researcher and the test will be terminated.
Despite being very rare, in some consumers the side effects of consuming the ingredients listed in the table above can cause dizziness, irritability, nausea, nervousness, jitters, nosebleeds, high blood pressure, low blood pressure, heart palpitations, breast pain, stuffy nose, restlessness and sleeping difficulty. Allergic reactions can include; rash, hives, itching, difficulty breathing, tightness in the chest, swelling of the (mouth, face, lips, or tongue), diarrhoea, shakiness, trouble sleeping, vomiting. Headaches and fatigue may be experienced from withdrawal.

Note: The beverages provided are off-the-shelf, available to all Americans across all of the United States with no age restriction

I have read and understand the statements above, declare that I am in good health, and agree to participate in the high altitude-training lab.

____ _____/_____/__________

Print Name Date

____

Signature

HIGH-ALTITUDE LABORATORY PARTICIPATION RELEASE FORM

1. I, _______________________________ (name), hereby acknowledge that I will participate in the use of a High Altitude Laboratory ("Lab") on the grounds of Embry-Riddle Aeronautical University (ERAU) in order to experience and learn about the physiological effects of unpressurized high altitude aviation. I understand that the effects of such experience may include, but not be limited to dizziness, nausea, rapid breathing, visual impairment, mental confusion and poor coordination. These effects are usually temporary, but since each person is different and has their own unique medical circumstances, I recognize that ERAU makes no representations as to how use of the Lab may affect me.

1. I agree that I am medically and otherwise fit to participate in the use of the high-altitude laboratory, and that I am free to decline to participate in any activity I deem too risky, dangerous, or ill-advised. My use of the Lab shall be conclusive evidence that I am fit and qualified to participate therein.

1. In consideration of permission to use the Lab, I hereby release, discharge, and hold harmless ERAU, its Trustees, Directors, officers, employees, agents, representatives, and successors in interest ("indemnified parties") from any and all claims of whatever kind or nature, including serious bodily injury or death, for any and all claims, demands, obligations, and liabilities arising from, connected with, or related to my participation in or use of the laboratory or any activity or event connected therewith.

1. I agree to defend and indemnify the indemnified parties on demand from any and all related claims, demands, obligations, and liabilities of whatever kind or nature. Additionally, I will not file, cause to be filed, participate in, permit, or cooperate with or in any action, claim, or demand against the indemnified parties for any act or event arising from, connected with, or related to my use of the Lab.

1. Any disputes arising from, related to, or in connection with this release or the activities to which it pertains shall be exclusively subject to the laws, jurisdiction, and venue of the State of Florida and County of Volusia. I agree to resolve any disputes between me and ERAU by means of mediation using a mutually agreed mediator. In the event of a failure of mediation for any reason, I agree that, in lieu of litigation in a court of law, the dispute shall be resolved by means of binding arbitration in which each side shall select an arbitrator to serve on an arbitration panel, and those selectees shall chose a third member of the arbitration panel who shall preside. The arbitration panel shall conduct the arbitration in accordance with the rules of the American Arbitration Association, and its ruling shall be final and binding upon the parties. Any part of this agreement that is deemed void or voidable shall be excised from this agreement and the remaining terms shall remain in full force and effect as though the excised term had never been included.

Signed: _____________________________________
Participant (print): Date
Witness:
(Printed): Date

ERAU OGC Approved
1-030609-7/000

Dear participant, for the purpose of this study you will be required to consume three separate beverages, in the table below is an exhausted list of the potential ingredients found within the beverages you will be required to consume. Please note that the ingredients listed may not be in the all of the drinks. Please carefully read the list and declare if you wish to participate in this Study.

Acacia	Milk Thistle extract
Ascorbic Acid	Niacinamide
Aspartame	Pannax ginseng extract
Biloba	Pantothenate
Benzoate	Pantothenic Acid
Berry Juice	Phosphorus
Fruit Juice	Potassium
Caffeine	Pyridoxine
Calcium	Riboflavin
Camitne	Sodium
Camitne Fumarate	Sodium Citrate
D-ribose	Sucrose
Ginkgo Biloba leaf extract	Taurine
Ginseng	Vitamin A
Glucose	Vitamin B2
Glucuronolactone	Vitamin B3
Glycerol Ester of wood rosin	Vitamin B5
Grape seed extract	Vitamin B6
Guarana extract	Vitamin B12
Guarana seed	Vitamin C
Inositol	Vitamin D
L-Arginine	Vitamin E
L-Carnitine	Vitamin K
Maltodextrin	Yerba mate leaf extract

I ………………………………….. declare that I have no known allergies or sensitivities to any of the ingredients found in the above list and wish to participate in this study. Initial……………
Please declare if you have any other known food or beverage allergies in the space allocated below.

……………………………………………………………………………………………….……...
……
……
……
……

Signed
………………………………………………………………………………………………………

Appendix D

HAL Setup Procedures

HAL set up procedures for Gainesville scenario

1. Turn on all the lights.
2. Open both HAL doors.
3. Between two people carefully carry the chair, located behind the HAL, to the simulator.
4. Retrieve the Gist laptop from its location behind the simulator.
5. Turn on the Gist Laptop.
6. Turn on the circuit breaker on the side of the simulator, immediately after turning on the Gist.
7. Wait for the communication channel to be reached, the screen will change colors until arriving at the default Runway 7L DAB.
8. Follow 172 setup checklists to initiate glass cockpit, ensure cockpit controls are set up for flight and ready for the scenario to begin.

Flaps – Up	Standby Battery – On
Mixture – Rich	Ignition – Both
Throttle – Full	Parking Brake – In
Trim – Neutral	Standby Static Source – In
Electrical Switches – Off	Fuel Shutoff – In
Master Switch – On	Fuel Selector – Both
Avionics Switch – On	FREEZE – Red Button ON
	On MFD – Press ENTER

Gist setup is complete.

9. To setup scenario on Gist laptop, begin on <u>ENVIRONMENT icon</u>. Click on CONDITIONS tab – set altimeter to 30.00. Click on CLOUDS tab – On the first layer, select overcast, set top to 10,000 ft, set bottom to 0 feet MSL, select red stop sign; it changes to green. VERIFY on Gist and *Mentor* Visual Display. Click on WINDS tab – consult approach plate and set top level wind 90 degrees left of the localizer (196 Degrees for GNV), select wind = 10 kts of wind, select gusts = 10 kts, repeat for second level and ground level, click DONE to confirm.
10. Select the <u>GLOBE Icon</u>, Position to Station – from list select appropriate VOR for scenario, (Ocala OCF for GNV). Set range from Station to 24.5, set the radial to 017, set the heading to 017, this is the same as the radial, select OK to confirm options. VERIFY on PFD.
11. Select aircraft <u>ATTITUDE icon</u>, consult approach plate and set initial altitude to be 1000 ft above the approach fix, (2700 for GNV), set heading to the lead-in radial, (017 for GNV), set pitch and bank to 0 degrees, set airspeed to 110 knots, select OK to confirm options.
12. On <u>Gist APPROACH display</u>, select the airplane symbol, search for the airport using the identifier, select the runway to be used, select OK and the airport will change on the Gist approach display.

13. The Experimenter must now select the **RECORD** icon, select the red button. Ensure that the simulator is recording (time advancing).
14. Set up is complete; now move the subject to the simulator chair with the appropriate approach plate.
15. The experimenter will now read the subject the ATC command – “On the Ocala 017 radial, descend and maintain 1700 Intercept the localizer, cleared for the ILS RWY 29 approach, altimeter 30.00, and squawk ………” (Participant number).
16. Tell the subject to press the red pause button and begin the approach.
17. Upon completion, select the RECORD icon, stop the recording, select file in the popup record window, save the file as participant number and date; select OK to save on hard drive.
18. In the popup record window, select FILE EXPORT, select the just-saved file name, Windows Explorer will open, find the external USB, select file copy, and it will save. When complete select OK, It will ask are you sure you want to quit, select OK.
19. Now experimenter must reset the simulator controls to flight-ready conditions. Repeat Steps 8-18 for next subject.
20. When the testing day is concluded, select FILE on the Gist toolbar, shut down trainer, YES, wait until the lap top is off, close the laptop and stow away behind the simulator.
21. Now turn off the simulator circuit breaker.
22. Carefully return the chair to the original position behind the HAL.
23. Sweep through the HAL to ensure it is returned to its original condition.

NOTE: If the simulator and the Gist fail to communicate select CTRL ALT DEL and select turn off the computer, if option is not present, a hard shut down will be ok, but not advisable.

REPORT HAL Problems to Glenn Harmon, phone: 6-6843
REPORT Gist/*Mentor* Problems to Tom Haritos, phone: 6-6447

HAL set up procedures for Jacksonville scenario

1. Turn on all the lights.
2. Open both HAL doors.
3. Between two people carefully carry the chair, located behind the HAL, to the simulator.
4. Retrieve the Gist laptop from its location behind the simulator.
5. Turn on the Gist Laptop.
6. Turn on the circuit breaker on the side of the simulator, immediately aeer turning on the Gist.
7. Wait for the communication channel to be reached, the screen will change colors until arriving at the default Runway 7L DAB.
8. Follow 172 setup checklists to initiate glass cockpit, ensure cockpit controls are set up for flight and ready for the scenario to begin.

Flaps – Up	Standby Battery – On
Mixture – Rich	Ignition – Both
Throttle – Full	Parking Brake – In
Trim – Neutral	Standby Static Source – In
Electrical Switches – Off	Fuel Shutoff – In
Master Switch – On	Fuel Selector – Both
Avionics Switch – On	FREEZE – Red Button ON
	On MFD – Press ENTER

Gist setup is complete.

9. To setup scenario on Gist laptop, begin on ENVIRONMENT icon. Click on CONDITIONS tab – set altimeter to 30.00. Click on CLOUDS tab – On the first layer, select overcast, set top to 10,000 ft, set bottom to 0 ft, select red stop sign; it changes to green. VERIFY on Gist and *Mentor* Visual Display. Click on WINDS tab – consult approach plate and set top level wind 90 degrees left of the localizer (164 degrees for JAX), select wind = 10 kts of wind, select gusts = 10 kts, repeat for second level and ground level, click DONE to confirm.
10. Select the GLOBE Icon, Position to Station – from list select appropriate VOR for scenario, (Craig CRG for JAX). Set range from Station to 8, set the radial to 006, set the heading to 006, this is the same as the radial, select OK to confirm options. VERIFY on PFD.
11. Select aircraft ATTITUDE icon, consult approach plate and set initial altitude to be 1000 feet MSL above the approach fix, (3000 for JAX), set heading to the lead-in radial, (006 for JAX), set pitch and bank to 0 degrees, set airspeed to 110 knots, select OK to confirm options.
12. On Gist APPROACH display, select the airplane symbol, search for the airport using the identifier, select the runway to be used, select OK and the airport will change on the Gist approach display.

13. The Experimenter must now select the **RECORD** icon, select the red button. Ensure that the simulator is recording (time advancing).
14. Set up is complete; now move the subject to the simulator chair with the appropriate approach plate.
15. The experimenter will now read the subject the ATC command – "On the CRAIG 006 radial, descend and maintain 2000 Feet MSL Intercept the localizer, cleared for the ILS RWY 25 approach, altimeter 30.00, and squawk ………" (Participant number).
16. Tell the subject to press the red pause button and begin the approach.
17. Upon completion, select the RECORD icon, stop the recording, select file in the popup record window, save the file as participant number and date; select OK to save on hard drive.
18. In the popup record window, select FILE EXPORT, select the just-saved file name, Windows Explorer will open, find the external USB, select file copy, and it will save. When complete select OK, It will ask are you sure you want to quit, select OK.
19. Now experimenter must reset the simulator controls to flight-ready conditions. Repeat Steps 8-18 for next subject.
20. When the testing day is concluded, select FILE on the Gist toolbar, shut down trainer, YES, wait until the lap top is off, close the laptop and stow away behind the simulator.
21. Now turn off the simulator circuit breaker.
22. Carefully return the chair to the original position behind the HAL.
23. Sweep through the HAL to ensure it is returned to its original condition.

NOTE: If the simulator and the Gist fail to communicate select CTRL ALT DEL and select turn off the computer, if option is not present, a hard shut down will be ok, but not advisable.

REPORT HAL Problems to Glenn Harmon, phone: 6-6843
REPORT Gist/*Mentor* Problems to Tom Haritos, phone: 6-6447

HAL set up procedures for St Augustine scenario

1. Turn on all the lights.
2. Open both HAL doors.
3. Between two people carefully carry the chair, located behind the HAL, to the simulator.
4. Retrieve the Gist laptop from its location behind the simulator.
5. Turn on the Gist Laptop.
6. Turn on the circuit breaker on the side of the simulator, immediately after turning on the Gist.
7. Wait for the communication channel to be reached, the screen will change colors until arriving at the default Runway 7L DAB.
8. Follow 172 setup checklists to initiate glass cockpit, ensure cockpit controls are set up for flight and ready for the scenario to begin.

Flaps – Up	Standby Battery – On
Mixture – Rich	Ignition – Both
Throttle – Full	Parking Brake – In
Trim – Neutral	Standby Static Source – In
Electrical Switches – Off	Fuel Shutoff – In
Master Switch – On	Fuel Selector – Both
Avionics Switch – On	FREEZE – Red Button ON
	On MFD – Press ENTER

Gist setup is complete.

9. To setup scenario on Gist laptop, begin on <u>ENVIRONMENT icon</u>. Click on CONDITIONS tab – set altimeter to 30.00. Click on CLOUDS tab – On the first layer, select overcast, set top to 10,000 feet MSL, set bottom to 0 feet MSL, select red stop sign; it changes to green. VERIFY on Gist and *Mentor* Visual Display. Click on WINDS tab – consult approach plate and set top level wind 90 degrees left of the localizer (222 degrees for SGJ), select wind = 10 kts of wind, select gusts = 10 kts, repeat for second level and ground level, click DONE to confirm.
10. Select the <u>GLOBE Icon</u>, Position to Station – from list select appropriate VOR for scenario, (Ormond OMN for SGJ). Set range from Station to 29, set the radial to 354, set the heading to 354; this is the same as the radial, select OK to confirm options. VERIFY on PFD.
11. Select aircraft <u>ATTITUDE icon</u>, consult approach plate and set initial altitude to be 1000 feet MSL above the approach fix, (4000 for SGJ), set heading to the lead-in radial, (354 for SGJ), set pitch and bank to 0 degrees, set airspeed to 110 knots, select OK to confirm options.
12. On <u>Gist APPROACH display</u>, select the airplane symbol, search for the airport using the identifier, select the runway to be used, select OK and the airport will change on the Gist approach display.

13. The Experimenter must now select the **RECORD** icon, select the red button. Ensure that the simulator is recording (time advancing).
14. Set up is complete; now move the subject to the simulator chair with the appropriate approach plate.
15. The experimenter will now read the subject the ATC command – "On the Ormond 354 radial, descend and maintain 3000 Ft Intercept the localizer, cleared for the ILS RWY 31 approach, altimeter 30.00, and squawk ………" (Participant number).
16. Tell the subject to press the red pause button and begin the approach.
17. Upon completion, select the RECORD icon, stop the recording, select file in the popup record window, save the file as participant number and date; select OK to save on hard drive.
18. In the popup record window, select FILE EXPORT, select the just-saved file name, Windows Explorer will open, find the external USB, select file copy, and it will save. When complete select OK, It will ask are you sure you want to quit, select OK.
19. Now experimenter must reset the simulator controls to flight-ready conditions. Repeat Steps 8-18 for next subject.
20. When the testing day is concluded, select FILE on the Gist toolbar, shut down trainer, YES, wait until the lap top is off, close the laptop and stow away behind the simulator.
21. Now turn off the simulator circuit breaker.
22. Carefully return the chair to the original position behind the HAL.
23. Sweep through the HAL to ensure it is returned to its original condition.

NOTE: If the simulator and the Gist fail to communicate select CTRL ALT DEL and select turn off the computer, if option is not present, a hard shut down will be ok, but not advisable.

REPORT HAL Problems to Glenn Harmon, phone: 6-6843
REPORT Gist/*Mentor* Problems to Tom Haritos, phone: 6-6447

Appendix E

Tables

Table 15

AATD Output Means for Gainesville

			Gainsville
Subject	Localizer Deviations	Glide-Slope Deviations	Airspeed Deviations
1	0.425	34.442	2.143
2	0.812	19.917	4.644
3	0.368	11.593	1.319
4	1.671	13.705	1.759
5	0.608	20.417	2.652
6	0.334	34.376	2.190
7	0.278	14.866	1.489
8	0.201	11.877	1.528
9	1.285	71.871	4.161
10	0.480	14.204	2.764
11	1.044	52.115	2.410

Table 16

AATD Output Means for Jacksonville

			Jacksonville
Subject	Localizer Deviations	Glide-Slope Deviations	Airspeed Deviations
1	0.384	11.632	1.760
2	0.707	39.259	4.444
3	0.378	27.587	2.014
4	0.368	8.250	2.444
5	0.608	11.001	1.550
6	0.574	43.600	1.880
7	0.185	14.394	0.860
8	0.175	18.826	3.210
9	1.172	37.843	5.472
10	0.266	8.061	0.737
11	0.706	366.443	15.336

Table 17

AATD Output Means for St Augustine

			St Augustine
Subject	Localizer Deviations	Glide-Slope Deviations	Airspeed Deviations
1	0.185	14.394	0.860
2	0.981	39.259	2.066
3	0.214	13.865	1.189
4	0.400	8.986	1.016
5	0.706	48.176	2.361
6	0.631	34.376	2.407
7	0.184	14.866	1.964
8	0.287	21.318	3.513
9	0.890	72.337	3.143
10	0.326	17.896	0.998
11	1.018	22.860	4.237

Table 18

AATD Output Means for Red Bull®

			Red Bull®
Subject	Localizer Deviations	Glide-Slope Deviations	Airspeed Deviations
1	0.425	34.442	2.143
2	0.981	39.259	2.066
3	0.378	27.587	2.014
4	1.671	13.705	1.759
5	0.706	48.176	2.361
6	0.574	43.600	1.880
7	0.278	14.866	1.489
8	0.287	21.318	3.513
9	1.285	71.871	4.161
10	0.326	17.896	0.998
11	0.706	366.443	15.336

Table 19

AATD Output Means for Monster®

Subject	Localizer Deviations	Glide-Slope Deviations	Monster® Airspeed Deviations
1	0.384	11.632	1.760
2	0.707	39.259	4.444
3	0.368	11.593	1.319
4	0.400	8.986	1.016
5	0.608	20.417	2.652
6	0.334	34.376	2.190
7	0.184	14.866	1.964
8	0.175	18.826	3.210
9	0.890	72.337	3.143
10	0.480	14.204	2.764
11	1.018	22.860	4.237

Table 20

AATD Output Means for Placebo

Subject	Localizer Deviations	Glide-Slope Deviations	Placebo Airspeed Deviations
1	0.185	14.394	0.860
2	0.812	19.917	4.644
3	0.214	13.865	1.189
4	0.368	8.250	2.444
5	0.608	11.001	1.550
6	0.631	34.376	2.407
7	0.185	14.394	0.860
8	0.201	11.877	1.528
9	1.172	37.843	5.472
10	0.266	8.061	0.737
11	1.044	52.115	2.410