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SUBMAXIMAL EXERCISE AND COGNITIVE FUNCTION TESTING AT ALTITUDE TO DETERMINE THE IMPACT OF DIFFERENT LEVELS OF HYPOBARIC HYPOXIA

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SUBMAXIMAL EXERCISE AND COGNITIVE

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A THESIS

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ABSTRACT

As an individual ascends to altitude, the partial pressure of oxygen in inspired air decreases and leads to a condition known as hypoxic hypoxia. This oxygen deficiency in the body can put aircraft crews at risk due to potential decrements in performance. Although extensive investigation has been done on the effects of hypoxia in humans, performance parameters at common general aviation (GA) altitudes have not been specifically investigated. This is reflected through discrepancies existing in the current Federal Aviation Regulations (FARs) concerning the use of supplemental oxygen in unpressurized aircraft. The purpose of this study was to investigate effects of altitude exposure and physical exertion on a human cognitive performance task. Fourteen individuals, eight females and six males participated in the study. Each subject was tested at ground level and at simulated altitudes of 8,000 feet, 10,000 feet, 12,500 feet, and 15,000 feet in a hypobaric chamber. A computer-based cognitive performance test battery, SYNWORK1, was used to assess performance. This test battery was comprised of four different mental tasks which were performed simultaneously. They included a short term memory task, a visual monitoring task, an auditory monitoring task, and an

arithmetic task. SYNWORK1 was administered three times during each test session: before and during altitude exposure, and while performing submaximal exercise (40% VO_{2max}) at altitude. Results were analyzed using a repeated measures analysis of variance design. Significant differences existed among the three conditions of the SYNWORK1 administration (ground level, altitude, altitude/exercise) of each test session. The results suggest that the effects of altitude may be specific to specific cognitive tasks. Exercise had a dramatic effect on SYNWORK1 performance at altitude. It is not clear if this decrease is a result of mental distractions associated with the physical activity, or lowered blood oxygen saturations associated with exercise at altitude.

SUBMAXIMAL EXERCISE AND COGNITIVE FUNCTION TESTING AT ALTITUDE TO DETERMINE THE IMPACT OF DIFFERENT LEVELS OF HYPOBARIC HYPOXIA

CHAPTER I

Introduction

The percentage of oxygen (21%) in the air remains virtually constant up to the outer edge of the earth's atmosphere. This does not mean that it is possible for a human being to continue breathing without assistance up to these altitudes. The partial pressure of oxygen decreases as atmospheric pressure falls during ascent to altitude. This decline in the partial pressure of oxygen decreases the amount of oxygen available to the body and leads to a condition known as hypoxia.

In low altitude conditions (5,000 ft. to 8,000 ft.), the body is able to deal with the slightly decreased partial pressures of oxygen in such a manner that very little or no difference in performance is detectable from sea level standards. However, as altitudes begin to increase (above 8,000 ft.), the mechanisms that respond to the decreased oxygen levels in the body may not be adequate to prevent decreases in performance. In order to ensure the highest level of safety for the individuals involved in aviation, it is very important to clearly identify the altitude where significant performance decrements appear.

Current research has been very ambiguous in the clear definition of where the effects altitude begin to cause harmful effects on performance. This is very evident when examining the discrepancies between various Federal Aviation Regulations (FARs) concerning flight limits for aircrew members without the supplemental use of oxygen. The regulation for general aviation states that individuals may ascend as high as 14,000 feet in an unpressurized aircraft for up to 30 minutes without the use of oxygen (FAR 91.32). Another regulation for air carrier aviation allows those individuals flying to ascend up to 12,500 feet for up to 30 minutes without the use of supplemental oxygen (FAR 121.39 and FAR 135.89).

One of the first areas affected in an individual is mental ability. This is due to the high oxygen requirements of the brain. Therefore, identifying a precise level at which an individual becomes affected becomes very crucial for performance reasons. The aircrew members also engage in a certain degree of physical exertion while in the air. The effects of this physical activity may also have an interaction on the performance of the individual.

Purpose and Significance of the Study

The purpose of this study was to examine the relationships between five different altitude exposures and cognitive performance and to examine the possible effects of physical activity at each altitude on cognitive performance. A better understanding of these relationships would lead to greater safety for individuals involved in aviation community and provide data which may help clarify current discrepancies in the regulations for supplemental oxygen use.

Research Questions

This study examined the effects of various different altitudes and submaximal exercise on the cognitive performance of fourteen different individuals. Three major research questions were explored.

The first question examined was whether or not an exposure to hypoxic conditions decreased the cognitive performance of the individual.

Ho: The cognitive performance of an individual will continue to decrease as the hypoxic conditions become more severe (altitude increases).

The next question examined was whether or not the introduction of submaximal exercise while administering the cognitive function test in hypoxic conditions further decreased the performance of the individual.

Ho: The introduction of submaximal exercise while administering the cognitive function test will significantly decrease the level of cognitive performance.

The final question examined was at what altitude the effects of the hypoxic conditions become significant in the cognitive performance of the individual.

Ho: The effects of the hypoxic conditions will cause significant detriments in cognitive performance beginning with the 8,000 ft. exposure.

Delimitations

1. Individuals who smoked were not allowed to participate.
2. Individuals who did not meet the minimum fitness standards determined by the VO2max test and class II airman's physical were not allowed to participate.

Limitations

1. The results of this study are not representative of individuals in poor health.
2. The results of this study may not apply to individuals who do not fall within the range of 20-36 years.
3. Although the processes used to test cognitive function represent similar tasks and actions involved in piloting an aircraft, it should be noted that they were not exactly identical.

Assumptions

1. The subjects in this study were comparable in health and age to pilots and aircrew of general aviation aircraft.
2. The subjects involved would provide a true reflection of self-report data and would put forth a maximum effort during the testing.

Operational Definitions

The following technical and physiological terms have been defined in an effort to make the reading of the study more understandable.

1. Hypoxia - Reduction of oxygen supply to tissue below physiological levels despite adequate perfusion of the tissue by blood (Dorland's Illustrated Medical Dictionary, 1988).
2. Hypoxic hypoxia - Hypoxia due to insufficient oxygen reaching the blood, as at decreased barometric pressures at high altitudes; also known as altitude hypoxia (Dorland's Illustrated Medical Dictionary, 1988 and DeHart, 1996).
3. Hypobaric chamber - A sealed space with external controls which regulate a vacuum pump that is used to regulate (lower or equalize) the pressure within the sealed space and simulate a given altitude.
4. Hypobaric hypoxia - Hypoxia induced with the use of a hypobaric chamber.
5. Cognition - That operation of the mind by which we become aware of objects of thought or perception; it includes all aspects of perceiving, thinking, and remembering (Dorland's Illustrated Medical Dictionary, 1988).

CHAPTER II

Literature Review

Conditions of increasing altitude place very severe demands on the pilots, aircrew, and passengers of aircraft without pressurized cabins. One of the greatest limitations of increasing altitude is the decreasing partial pressure of oxygen (O_2). This situation leads to a physiological state where there is an inadequate amount of oxygen for the proper function of the body's systems, known as hypoxia (Campbell and Bagshaw, 1991). Hypoxic hypoxia is the condition in which there is an insufficient amount of oxygen exchanged at the alveolar level. The decrease in the partial pressure of the inspired air leads to a reduced pressure gradient for the oxygen diffusion between the alveoli in the lung and the capillaries that meet the alveoli. This equates to a reduced quantity of oxygen carried by the circulating blood. This effects the body at the tissue level, as a smaller amount of oxygen is delivered. This condition is also referred to as altitude hypoxia because it is caused by the decreasing barometric pressure that accompanies increasing altitude (DeHart, 1996).

The symptoms of hypoxia can range from feelings of intoxication and decreased reactions times to unconsciousness. The signs and symptoms of hypoxia are varied between different individuals. One individual may experience drowsiness and decreases in night vision much more severely than another individual at the same altitude exposure. Loss of cognitive abilities up to and including unconsciousness can obviously lead to accidents or even fatalities in the aviation environment.

A rapid or explosive decompression is normally a very traumatic event and an occurrence like this automatically signals the aircrew of the need to don oxygen support while still conscious. Conversely, many smaller corporate and civilian aircraft are not equipped with pressurized cabins and fly at altitudes where the effects of hypoxia may represent a significant risk. The current Federal Aviation Regulation (FAR) 91.32 dictates that individuals in the general aviation environment may go above 12,500 feet MSL and up to 14,000 feet MSL for thirty minutes without supplemental oxygen. FARs 121.329 and 135.89 also state that individuals in air carrier aviation may go above 10,000 feet and up to 12,000 feet for thirty minutes without supplemental oxygen. There are certain situations such as when flying over mountainous terrain or attempting to avoid inclement weather, aircraft without pressurized cabins may fly at altitudes which could possibly cause hypoxia. In situations such as these when a gradual ascent is made, the onset of the symptoms of hypoxia is insidious.

The brain, the eyes, and the heart maintain the highest demand for oxygen, and therefore, are the areas first and most dramatically affected by a lack of oxygen. The effects of the hypoxic conditions are directly proportional to the duration and intensity of the exposure to the high altitude environment. These effects are often very difficult to detect because they occur very gradually and are not accompanied by discomfort or pain. Intellectual impairment is one of the initial characteristics of hypoxia, and the nature of this decreased judgment often make it difficult for the individual to detect the condition (DeHart, 1996).

Numerous factors contribute to the total effect for hypoxic stimuli. These include both internal and external factors. Altitude, rate of ascent, time spent at altitude, environmental temperature, and amount of physical exertion are factors which are independent of the individual and will influence the degree of hypoxia. There are also factors which influence the state of hypoxia that are dependent upon the individual. These factors include the individual's level of physical fitness, emotional state, alcohol consumption, tobacco consumption, presence of drugs or medication in the system, nutritional status, level of fatigue, and the degree to which the individual has been acclimatized to the environment (DeHart, 1996). For these reasons, hypoxia affects each individual differently. Some individuals may show signs of hypoxia at lower altitudes than do other individuals. This individuality has also made it difficult in selecting standards at which supplemental oxygen should be used.

Due to variability, characterizing consistent guidelines that distinguish where hypoxia brings about decrements in performance has been difficult. A critical factor in dealing with the effects of hypoxia is recognizing the symptoms which indicate that an individual is being affected. Various questionnaires have been shown to be effective instruments in identifying symptoms caused by altitude exposure. Kobbick and Sampsom (1979) described the Environmental Symptoms Questionnaire (ESQ) as a sufficient tool in detecting a broad spectrum of symptoms caused by exposure to altitude. In a study of twelve subjects exposed to an altitude of 14,000 feet, they found that the questionnaire was both easier to use and better equipped for evaluating the effects of altitude exposure compared to a similar questionnaire called the General High Altitude Questionnaire (GHAQ). This was due mainly to the fact that the GHAQ was found to be extremely long and the ESQ had a higher level of sensitivity to the altitude questions. The ESQ was better able to detect changes in altitude symptom severity. The ESQ also surveyed certain states of the individual's mood such as boredom and irritability, which could prove to be useful in the research. A problem that may arise is boredom and passiveness may cause an individual to do poorly on the cognitive testing (Kobrick & Sampson, 1979).

Many different tasks have been employed with the purpose of measuring the cognitive performance of an individual. Shukitt, Burse, Banderet, Knight, and Cymerman (1988) used addition batteries, computer interaction, number comparison, pattern comparison, and pattern recognition in order to gauge cognitive performance. There are many different aspects involved in flying an aircraft which resemble many of these tasks. They include: reading and monitoring instruments and gauges in the aircraft, tracking traffic outside the aircraft, maintaining communication with other aircraft or the tower, and actually flying the aircraft. At most times during a flight a pilot is required to perform many of these different mental tasks at once. Each one of these mental tasks require a certain amount of the pilot's cognitive function. For this reason, any loss or decrement on the pilot's normal mental capacity because of hypoxic conditions could prove to be disastrous.

Synwork1 is a program that has been used to assess cognitive performance in individuals exposed to different environments and different stressors. This software program, which is designed to assess multi-task performance is very easy to install on a personal computer. The program needs only the assistance of a mouse and a sound card. It is a much more accessible option to some of the more conventional Performance Assessment Batteries (PABs) (Englund, Reeves, Shingledecker, Thorne, Wilson, & Hegge, 1985). The PABs are usually limited to one machine or unit. These machines are usually very cumbersome and difficult to move around. The expense may also become extreme when attempting to possess multiple machines. In addition to these drawbacks, Elsmore, Naitoh, and Linnville (1993) have also indicated that the Synwork1 evaluation tool may be more effective in measuring ability. Many of the PABs deal with only one task, while the actual aircraft flight deck environment usually requires an individual to monitor and respond to many different stimuli at the same time. The Synwork1 program is a multitask environment which requires the subject to perform a combination of tasks simultaneously. The program consists of a memory task, an addition task, a visual monitoring task, and an auditory monitoring task. Other tests such as the past Multiple Task Performance Batteries (MTPB) have tested combinations of tasks at the same time, however, these tests have had a very limited application because they were contained in a unique hardware apparatus. This apparatus could not be applied in different places and different assessment situations at the same time (Elsmore, Naitoh, & Linnville, 1993).

In the aviation environment, pilots and aircrew members may be required to exert a certain amount of physical effort in order to control the aircraft, especially in emergency situations. During these situations it is possible that the combined effects of physical exertion and the hypoxic environment will lead to a greater potential for mistakes. For this reason it is important to examine how exercise affects cognitive performance, how hypoxia affects cognitive performance, and how they might interact to cause performance detriments.

Exercise and Cognitive Performance

Although the strength and aerobic requirements involved in piloting or working aboard an aircraft may be comparatively small, physical activity levels are increased above rest. There is a great deal of concentration involved in maneuvering an aircraft. In certain tense situations like an inclement weather situation, an in-flight fire, or an equipment failure, the pilot may be required to engage in a larger amount of physical activity for extended periods of time. Therefore, a very important question is whether or not physical activity influences cognitive performance.

Sparrow and Wright (1993) examined the effects of a short duration of aerobic exercise on cognitive performance. They administered two different cognitive tasks to four different groups of subjects (two who would exercise and two who were controls). The control included either playing bingo or remaining inactive. The tests were administered again after the control or the exercise session was completed. Their data analysis showed that there was not a significant difference in the fitness levels of the subjects and there was not a significant difference between pretest and post-test for each group or between the groups. These results suggested that there was not a difference between the experimental and control group and therefore, the short duration aerobic exercise bout did not improve or decrease cognitive performance (Sparrow & Wright, 1993).

Heckler and Croce (1992) examined the effects of exercise on mental ability in women of different fitness levels. Nine subjects were placed into a fit group, while another nine subjects were placed into the less-fit group. The fit subjects had a VO_2max of ≥45 ml/kg/min and the less fit subjects had a VO_2max of <40 ml/kg/min. Each subject completed 20 randomly generated arithmetic problems on a personal computer immediately after, 5 minutes after, and 15 minutes after, a 20 minute exercise session on the treadmill at 55% of VO_2max. Speed was measured by the average amount of time it took for the subject to complete each problem. Accuracy was graded by the number of incorrect responses out of the 20 problems. They found that it took the less-fit women longer to complete the cognitive task after a bout of exercise and the less-fit women also exhibited a trend of greater mistakes on the cognitive tasks. This data suggests that the fitness level of the individual may have an effect on the mental performance of the individual after a bout of exercise.

Tomporowski and Ellis (1986) completed a review of over twenty-five studies which examined the effects of exercise on cognitive performance. As one might expect, the studies are conflicting in their results. One particular study (McGlynn, Laughlin, & Rowe, 1972) has suggested that cognitive function is improved both during and after exercise. In contrast, some studies (Gutin & DiGennaro, 1968 and Sjoberg, 1980) propose that exercise decreases cognitive ability. There are still others which maintain that cognitive functioning is unaffected by exercise (McAdam & Wang, 1967). Tomporowski and Ellis suggest that results may depend on the time at which the test is administered, the intensity of the exercise, the duration of the exercise, and the fitness level of the individual. The arousal of the central nervous system which accompanies initial levels of physical exertion may increase cognitive function, but these added benefits may be outweighed by muscle fatigue (Tomporowski & Ellis, 1986).

Altitude and Exercise Performance

The interplay among hypoxia, exercise, and cognitive ability is further complicated by a decrement in the body's physical performance caused by increasing altitude. There is an increase in resting minute ventilation when the partial pressure of the inspired air dips below 110 torr (10,000 feet). The decrease in the partial pressure results in a smaller amount of oxygen being carried to the cells. This requires that the cardiac muscle work harder. This also means that at any altitude an individual will work at a higher percentage of VO_2max. It is possible that physical impairment could further complicate the problems which occur in hypoxic conditions due to a reduction in cognitive ability. When the hypoxic conditions cause the individual to further exert himself/herself to meet the demands of the situation, it could lead to further degradation of the individual's cognitive ability. This relationship could be very crucial in the overall performance of a pilot and the aircrew.

As altitude increases, the partial pressure oxygen in the air decreases. This decrease in the partial pressure of oxygen can directly lead to decrements in physical performance. Lawler, Powers, and Thompson (1988) compared levels of maximum oxygen uptake for endurance trained athletes and non-endurance trained athletes at sea level conditions and at conditions of acute hypoxia. Both the trained group and the untrained group experienced increasing decrements in VO_2max with increasing altitude, but their results indicated that the increased altitude had a greater detriment on the endurance trained athletes. When exercising at altitude, the blood oxygen saturation of the of trained athletes was much lower than the values for the untrained group (Lawler, Powers, & Thompson, 1988). This data suggests that aviators with higher aerobic capacities are more susceptible negative effects due to hypoxic conditions.

Altitude and Cognitive Performance

As altitude increases, the effects of hypoxia become more severe. One explanation is that at higher altitudes cognitive performance would be decreased to a greater degree due to less oxygen delivered to the cells and tissues. An extremely important question is at what altitude do the negative effects of hypoxia begin to affect the cognitive performance of an individual. A study by Kelman and Crow (1969) examined the differences between the performance of individuals on a mental task at 8,000 feet and the performance of individuals on the same test in normal conditions (2,000 ft). The mental tests used by the researchers included a "simple" test and a "more difficult" test where the subjects were required to find designated letter pairs from rows of random text. The subjects were not informed of the altitude at which the tests were administered. The subjects who performed the easier test did not show a significant difference in performance between the 2,000 feet exposure and 8,000 feet exposure. The subjects who performed the more difficult test at 8,000 feet had markedly worse results on the first part of the testing compared to the 2,000 feet group. After becoming acquainted with the test, the results between the 2,000 feet group and the 8,000 feet group on the difficult task did not differ. From their results, they suggested that the increased altitude diminished the learning ability of the subjects (Kelman and Crow, 1969). It is possible, however, that the differences in the scores were not caused by differences in altitude but differences between the subjects in the two groups. A test administered before the actual altitude testing to compare the abilities of the subjects may have been helpful in determining the cause of the differences.

A study by Kelman, Crow, and Bursill (1969) also examined the effects of an 8,000 foot environment on a mental task. The mental task in their experiment involved sorting a pack of cards which were designated with different numbers and letter patterns. Although there was not a significant difference, the average amount of time taken by the group of subjects at 8,000 feet was faster compared with the average time of the subjects from the control group.

The control group worked in an altitude equivalent to 2,000 feet, but neither the groups nor the observers knew the altitude at which the test was administered. Because there was not a statistically significant difference between the 8,000 feet group and the 2,000 feet group, the authors suggested the possibility that detrimental effects caused by slight hypoxia may be dependent on the task performed by the individual (Kelman, Crow, and Bursill, 1969). It is possible that the differences in the groups' times were caused by individual differences between subjects. The authors also suggested that the difficulty of the test or task could play a role in whether or not the altitude has a detrimental effect on cognitive performance (Kelman, Crow, and Bursill, 1969).

Fowler and Porlier (1987) attempted to determine the point at which the decreases in the partial pressure of oxygen, which occur with increasing altitude, affect perceptual-motor performance. Perceptual-motor performance was measured with a serial choice response time task (SCRT). The scores on the perceptual-motor tasks measured by the SCRT declined proportionally to the increase in altitude. Altitude was simulated by having the subjects breath a hypoxic gas mixture through an oral mask. The mixture corresponded to the designated altitude of 15,000 feet. The results suggested that the threshold for detrimental effects from hypoxia was an SaO_2 level of approximately 83%, which occurs at approximately 14,500 feet. They also found that the detriments occurred at a greater rate when the test was administered in a dimmer condition compared to a brighter environment. The results are consistent with a related study by Fowler, Taylor, and Porlier (1987), which suggested that reaction time was slowed by hypoxic conditions. In this study they also proposed that an environment which decreased lighting adds to the decrement in reaction time with increased altitude (Fowler, Taylor, & Porlier, 1987). This supports literature (Fulco & Cymerman, 1987) which stated that visual acuity is highly sensitive to hypoxic conditions and that in insufficiently lighted environments decrements may begin at 7800 feet. Decreasing visual acuity could lead directly to mistakes in the cockpit during flight and these decrements may be increased in low light conditions such as during night flight.

A study by Liberman, Miles, Nims, and Wesley (1947) examined the effects of increasing altitude on cognitive performance. Fifteen subjects were given various cognitive tests at the following altitudes: 3,000 feet, 10,000 feet, 13,000 feet, and 16,000 feet. The cognitive tests consisted of two tests of intellectual function and one test of psychomotor performance. The first intellectual test was a complex cancellation task involving 15 rows of 15 numerals. The next intellectual test administered was the Otis Self-Administering Test of Mental Ability. The Miles pursuimeter test was used to measure psychomotor ability. In order to eliminate errors caused by learning, the subjects were given prior experience on the tests and experience in the altitude chamber. Knowledge of the current altitude was also withheld from the subjects during the testing. This was done in attempts to minimize possible errors in the results. It is possible that some subjects would attempt to increase their concentration at higher altitudes because they knew that hypoxic conditions became more severe at higher altitudes. The subjects did not show any decrements in performance at altitudes up to 13,000 feet. At 16,000 feet, the subjects had an average decrease of greater than 30% on their intellectual tasks. The results indicated that the interval between 13,000 feet and 16,000 feet is critical in the effects caused by a decreased partial pressure of oxygen. The study also examined the oxygen desaturation of the blood with increasing altitude and how it affected performance. As expected, the level of oxygen saturation decreased with increasing altitude. There was an overall negative correlation between the level of oxygen desaturation and both intellectual tests. The decreases in performance on the intellectual tests were smaller as the oxygen saturation in the blood of the subject decreased. The study showed that there was greater impairment as the amount of oxygen-blood saturation decreased (Liberman, Miles, Nims, and Wesley, 1947).

Noble, Jones, and Davis (1993) tested the effects of decreased blood-oxygen saturation on cognitive performance. The experimental group completed four mental tasks after they had breathed a gas mixture, which decreased their oxyhemoglobin saturation. The gas mixture was adjusted to obtain arterial oxygen saturation (SaO_2) of 80%. Although the decrements were minor, cognitive performance was decreased in the oxygen-deprived group. There was a decrease in reaction time in the subject group, which was subjected to hypoxic conditions. This group also demonstrated a decreased score on one of the cognitive tasks when it was repeated compared to the group under normal conditions who increased their scores when the test was repeated. The authors suggested that the hypoxic conditions could result in a decreased cognitive function. The complexity and difficulty of the tests, or lack there of, may have influenced the degree of performance decrement. It is possible that the subjects would have experienced greater decreases in performance if the tests would have been more challenging or if the tests involved more than one skill item at a time (Noble, Jones, & Davis, 1993).

A study by Fiorica, Burr, and Moses (1971) examined the effects of altitude on the ability of an individual to respond to a programmed stimulus. The authors suggested that the stimulus, which included responding to a simple light display, could represent or resemble a device that a pilot or air crew member may be required to monitor during a normal flight. Physiological parameters including heart rate, ventilation rate, body temperature, glucose concentrations, lactate levels, and blood oxygen saturation were also measured. The results indicated that the subjects tested at altitude of 11,500 feet were not affected by the environmental conditions and scored similarly on the test compared to the subjects tested at ground level. The blood-oxygen saturation levels of the subjects tested at altitude were significantly lower than normal levels and this could be interpreted as a sign of mild hypoxia. This study did suggest that a very simple mental task was not influenced by an environment of 11,500 feet, but other factors such as increased levels of physical exertion and more difficult mental duties may be required in an actual flying experience (Fiorica et al., 1971).

Cahoon (1972) performed a study in which eight subjects were exposed to an environment of 15,000 feet. The subjects were given the same cognitive tests after the following exposure times: 3 hours, 20 hours, 24 hours, and 45 hours of exposure. These tests involved card sorting tasks of varying complexity. Tests were administered to the subjects at a sea level environment before entering the high altitude environment. The tests were administered again after set time periods following the initiation of altitude exposure. Cahoon found that the greatest decreases in scores came after three hours at 15,000 feet. The subjects scored lower in both the time required to complete the test and the number of correct responses. The decrements in performance were also greater for the more complicated tests. The scores improved in the later testing sessions at 15,000 feet. These increases in performance could have been due to both an increased understanding of the tasks and a physical adaptation to the high altitude (Cahoon, 1972). The results of this experiment are important as they suggest that the duration of altitude exposure is important to possible decrements in the individual's performance.

Another study (Bonnon, Noel-Jorand, & Therme, 1995) investigated the effects of chronic hypoxia or longer durations spent at altitude. The results closely support the conclusions of Cahoon (1972). In this study, a group of six individuals were administered a cognitive function task in normal conditions, after an ascent to an altitude exceeding 11,000 feet, and after two days spent at that altitude. The hypoxic subjects' test scores did not significantly increase or decrease between the first and second administrations, but did improve on the third instance. The control subjects were tested each time in normal conditions and their scores increased between the first and second testing. The authors proposed that what the subjects learned by taking the test at ground level was interfered with in the initial exposure to the hypoxic conditions but there was an adaptation to the high altitude with a sustained duration of time (Bonnon, Noel-Jorand, & Therme, 1995).

Altitude, Exercise, and Cognitive Performance

Denison, Ledwith, and Poulton (1966) examined the combined effects of altitude and exercise on a mental orientation test. The researchers simulated the selected altitude by placing the subject on a mask which delivered a mixture of gas resembling the designated altitude. While the subjects were taking the orientation test, they were required to peddle an exercise cycle which was set at 70 rpm/minute. This exercise was administered in order to simulate the metabolic demands which may be placed on a pilot while flying. They found that during the initial tests, the subjects who were at a simulated altitude of 8,000 feet had slower response times and they committed a larger number of errors compared to the subjects under normal partial pressures of oxygen. As the testing continued, the performance of the subjects at 8,000 feet matched the performance of the subjects who were under normal conditions. Similar results were also found for the same study at 5,000 feet. From their findings, the researchers suggested that the effects of hypoxia were detectable only when the subjects were required to understand and master an unfamiliar and complicated task. These results could be very significant to a pilot flying at altitude who encounters demanding circumstances (Denison, Ledwith, and Poulton, 1966).

Fowler, Paul, Porlier, Elcombe, and Taylor (1985) performed a follow-up study concerning the altitude at which the effects of hypoxia are detectable in performance. They repeated the experiment performed by Denison et al. (1966) under the same conditions excluding the workload. Their results showed that reaction times were not affected when the workload was not applied, but they were slowed when the subject was exposed to the exercise. They argued that the interactive affects of altitude, exercise, and the resistance caused by the breathing apparatus caused the decreased reaction time, and that the hypoxic conditions at 8,000 feet did not cause detrimental effects on performance in the absence of exercise. The results indicated that the distraction caused by the exercise was the reason for the detriments in cognitive performance (Fowler, Paul, Portlier, Elcombe, & Taylor, 1985).

A study by Higgins, Mertens, McKenzie, Funkhouser, White, and Milburn (1982) examined cognitive performance at an altitude of 12,500 feet following an hour of exercise. The altitude was simulated by having the subjects breath an oxygen/nitrogen mixture comparable to 12,500 feet. Control subjects breathed an oxygen/nitrogen mixture similar to ground level. Cognitive performance was measured by using the Multiple Task Performance Battery (MTPB). They found that cognitive performance was slowed at the 12,500 feet altitude regardless of whether or not the subject had exercised prior to the testing at 12,500 feet. The bout of physical exertion before the testing did not appear to decrease the ability to perform mental tasks as there was not a statistically significant effect on the test scores. They did note that the exercise session before entering the high altitude environment may have increased the cardiovascular circulation of the subject and resulted in a defense against the effects of hypoxia. This was seen when the scores of the no exercise subjects continued to decrease after the first test session at 12,500 feet, while the exercise subjects exhibited much higher scores in the later sessions at high altitude. The authors suggested that the increased heart rate and blood flow that accompanied the exercise may have acted to alleviate the detriments caused by the decreased oxygen saturation of the blood, which occurs with increasing altitude. Concerning the applied exercise, it is possible that the intensity level was not high enough and the duration was not long enough to cause a difference in the test score results. The recovery period allotted between the exercise session and the testing at altitude may also have been an adequate amount of time for the individual to recover. These issues are of concern as the pilots or aircrew members could be directly influenced by levels of fatigue before ascending to altitude in an unpressurized aircraft (Higgins, Mertens, McKenzie, Funkhouser, White, and Milburn, 1982).

Lategola, Lyne, and Burr (1982) completed a study on ten men in order to investigate the effects of an hour of physical exertion on tolerance to hypoxia, orthostatic stress, and further fatigue. Each subject completed four 10 minute periods of cycle ergometry with five minutes of rest between each period. The 10 minute periods were broken down into 2 minutes at 30 watts, 4 minutes at 60 watts, and for minutes at 100 watts. The rpm's were maintained at 50 throughout the 10 minute period. The subjects then completed four psychomotor tests while they were breathing a gas mixture which simulated an altitude of 12,000 ft. Although there was a trend which indicated that the subject's psychomotor performance was reduced due to the prior exercise, there was not a statistically significant effect present. They found that the exercise did not decrease the body's ability to deal with hypoxic conditions, its mental functioning capability, or the susceptibility for further fatigue from exercise (Lategola, Lyne, & Burr, 1982). These results agreed with the data presented in the related study by Higgins, Mertens, McKenzie, Funkhouser, White, and Milburn (1982), which also showed that exercise prior to a bout of exercise at altitude did not decrease cognitive performance.

Paul and Fraser (1994) studied the effects of various altitudes and the presence or absence of exercise on the ability of an individual to learn a new task at low altitudes. The subjects were administered a spatial orientation test, a logical reasoning test, and a serial choice reaction time test. Altitude was simulated with a hypobaric chamber. Their results indicated that the response times for the exercising individuals tended to be slower, and the increasing altitude did produce signs of hypoxia (lower oxyhaemoglobin saturation). However, there was not a significant decrease in the individual's capacity to learn a new mental task at altitudes reaching 12,000 feet (Paul & Fraser, 1994). This information may be important in situations where the pilot or aircrew are in an unfamiliar environment and are not accustomed with a procedure. In these situations, which are very likely in an emergency, it may be necessary to learn a new process or procedure.

Knight, Schlichting, Dougherty, Messier, and Tappan (1991) studied the effects of hypoxia on cognitive tasks while exercising at the simulated altitude equivalent of 14,764 feet. The subjects exercised at increasing submaximal levels on a bicycle ergometer. The subjects breathed either a normoxic gas mixture (control) or a mixture containing 11.8% oxygen during the experimental period. An arithmetic mental test was used to determine cognitive performance. The subject's cognitive test scores significantly decreased during exercise in hypoxic conditions. These results agree with previous studies which also indicated a decrement in cognitive performance during exercise in hypoxic conditions (Denison, Ledwith, & Poulton, 1966 and Fowler, Paul, Porlier, Elcombe, & Taylor, 1985). The authors suggested that the declines were due primarily to the hypoxic conditions and not the exercise. This suggestion was based on the fact that exercise at normal conditions did not improve or worsen the scores. The drops in the scores did not occur until the hypoxic conditions were introduced (Knight, Schlichting, Dougherty, Messier, and Tappan, 1991). It is possible that the main cause of the performance decrement was the hypoxic conditions, but the pilots and aircrew engage in a certain amount of physical activity while flying. Exercise is used to simulate that physical exertion which the pilots and aircrew may encounter.

Additional Considerations

In addition to detriments caused by altitude and physical exertion, it is possible that cognitive performance may also be affected by factors such as age, health status, mood state, fatigue level, and other environmental conditions. Spieth (1964) studied over 600 individuals of various degrees of cardiovascular health and ages ranging from 23 to 59 years. After the subjects performed a variety of cognitive tasks, Spieth concluded that the subject's scores declined with age and with decreasing cardiovascular health. The healthy subjects had only mildly decreasing test scores as age increased. The subjects with cardiovascular disease (CVD) were responsible for the majority of the descending trend in the psychological test scores. In addition, subjects who were fully recovered from a serious illness and had only mild or slight CVD symptoms showed performance deficiencies. Based on these results, he concluded that the major factor in the decreasing scores was the presence of disease and not the increased age. As one would expect, he found a trend toward increased disease as age increased. This study raised the importance of considering the age and the cardiovascular status of an individual before completing a study involving the cognitive processes. This increases the seriousness of this issue and should make it a very important consideration when examining performance (Spieth, 1964).

Mertens and Collins (1986) examined the possible interactive effects of age, sleep loss, and increased altitude on Multiple Task Performance Battery (MTPB). The various conditions included: two age groups, 30-39 years and 60-69 years; two sleep conditions, deprived of a night of sleep and a night of regular sleep; and two altitude conditions, ground level and 12,500 feet. Each subject completed at least 21 hours of training on the MTPB before the testing began. There were two groups: a group of younger subjects (30-39 years) and a group of older subjects (60-69 years). Each group underwent four different testing sessions: the testing at ground level after a normal night of sleep, the testing at altitude (12,500 ft.) after a normal night of sleep, the testing at ground level after being deprived of a night of sleep, and the testing at altitude (12,500 ft.) after being deprived of a night of sleep. The researchers found that there was not a significant decrease in performance due to the effects of altitude alone. There was a significant decrease in performance due to the fatigue from losing a night of sleep. The older subjects also showed significantly lower scores and were more affected by an increasing workload on the MTPB. Most importantly, there was an interactive negative effect of altitude and sleep deprivation on performance. Although the idea is widely accepted that optimal performance requires proper rest, the data from this experiment is very important for pilots as they may be more affected by fatigue due to increased altitudes.

There are also other factors that could also lead to decrements in cognitive function in an aviation environment. Cognitive performance could be further decreased in situations were an aircraft experiences a gas leak or a problem with the exhaust system and exposes the pilot or aircrew to carbon monoxide or other harmful fumes. Bunnell and Horvath (1988) suggested that exposure to increased levels of carbon monoxide can lead to impairments in certain cognitive functions. They examined the effects of low levels of carbon monoxide on the mental performance of individuals. Their results suggested that the symptoms of carbon monoxide exposure are often not obvious to the individual but exposure may result in a diminished mental capacity and visual function. The decreases appeared to be proportional to the amount or concentration of the gas (Bunnell & Horvath, 1988).

A final important consideration that should be taken into account is the possibility that the environment may affect bodily functions other than those regulating physical and mental performance, and these factors may also play a role in the overall condition of the individual. Shukitt and Banderet (1988) examined the effects of altitude on the mood states of individuals. All subjects were examined for two days at 656 feet and then one group of subjects was monitored for two days at 4,600 feet, while the other group was monitored for four days at 14,100 feet. The results showed that the only mood difference at 4,600 feet was an initial increase in sleepiness, which later returned to the baseline level (656 feet). At 14,100 feet, the subjects reported decreases in the following categories: clear thinking, dizziness, and friendliness. These measures also returned to baseline levels after two days at the altitude. This study suggested the mood states of individuals are affected after the initial exposure to hypoxic conditions (Shukitt & Banderet, 1988). These results are important because it is possible that these observed changes in mood state could directly influence cognitive performance on a test at that altitude.

Cahoon (1973) investigated the effects of graded hypoxic conditions on the ability of an individual to discern auditory signals. He found that as the duration of the auditory test lengthened (2 hour period) and the degree of hypoxia increased (from sea level to 17,000 feet), the scores on the auditory tests decreased. Because the reaction times between normal conditions and hypoxic conditions did not differ, Cahoon suggested that the hypoxia decreased the ability to remain attentive and not necessarily the ability to determine changes in the auditory signal (Cahoon, 1973).

Fraser, Eastman, Paul, and Porlier (1987) examined the possible interaction between altitude and the postural control system. During five different test sessions, the subjects were tested at ground level and at the following four altitudes: 5,000, 8,000, 10,000, and 12,000 feet. Compared to ground levels, sway of the individuals increased significantly at 5,000, 8,000, and 10,000 feet. There was not a significant difference between the ground level values and the values at 12,000 feet. These results suggest that the hypoxic conditions do affect postural control, but the body is able to adapt to the altitude changes with increased degree of exposure or greater intensities of hypoxia (Fraser, Eastman, Paul, & Porlier, 1987). The small decreases in the partial pressure of oxygen with increasing altitude may cause a faint change in the normal cerebral metabolism and initiate a cascading effect. The change in metabolism would cause a decrease in the synthesis of neurotransmitters, which would lead to impairment of the normal vestibular and postural function (Fraser, Eastman, Paul, & Porlier, 1987). An altitude of 12,000 feet may be enough of a hypoxic condition that triggers compensatory mechanisms. An increase in cerebral blood flow may compensate for the changes caused by the drops in the partial pressure of oxygen. These results are extremely important to pilots, as, the vestibular system is crucial in their ability to maintain the orientation of the aircraft (Fraser, Eastman, Paul, & Porlier, 1987). Any disruption of the vestibular system could result in a condition known as spatial disorientation. Spatial disorientation is the condition in which the body senses false movement. It is caused by changes in the dynamics of the vestibular system, specifically the semicircular ducts and the otolith organ.

Summary

There are numerous factors that must be considered when examining an individual's performance during exposure to hypoxic conditions. Therefore, a valid assessment of the effects of hypoxia should attempt to take as many of these factors into account as possible. In order to find results which may aid in the determination of when supplemental oxygen should be used, a situation similar to the one a pilot or aircrew member may experience in the cockpit should be established. This situation will most definitely include a complex mental task that involves more than one cognitive ability and a certain amount of physical exertion to maneuver the aircraft.

Exposure to altitude is an inevitable part of aviation. With the benefits and convenience of ascending into the sky in an aircraft, come the risks of operating in what can be hostile surroundings. There is no argument about the relationship between altitude and the partial pressure of oxygen. As the altitude increases, the partial pressure of oxygen decreases. At some point, this environmental change will adversely affect the individual who is exposed to it. Although the lives of the pilots, aircrew, and passengers may not be in direct danger due to the effects of low altitude hypoxic conditions, it is possible that conditions such as this may lead to a greater potential for error in performance. As some aircraft fly without supplemental oxygen, the point at which the impairments begin to occur becomes very crucial. The results of such research may lead to a safer, more secure environment for the individuals who pilot and fly aboard these aircraft.

CHAPTER III

Research Design and Methodology

The design of the study was constructed in a fashion to test the effects of increasing altitude in combination with physical activity on the cognitive performance of an individual. The fourteen subjects were tested at ground level and simulated altitudes of 8,000 feet, 10,000 feet, 12,500 feet, and 15,000 feet. The SYNWORK1 cognitive test battery was used to assess performance. The SYNWORK1 test consisted of four different mental tasks which were performed simultaneously. This cognitive function test was administered three times during each test session: before and during altitude exposure, and while engaged in submaximal exercise (40% VO_2max) at altitude. Results of the testing was analyzed using a Repeated Measures Analysis of Variance.

Subjects

Both males and females participated in this study. Six males and eight females between the ages of 20 and 36 years were recruited from the local area for the study. A local agency was used to recruit the subjects for the Environmental Physiology Research Team at the Civil Aeromedical Institute (CAMI), Mike Monroney Aeronautical Center, FAA. This agency reimbursed the subjects for their participation and the agency was in turn paid by the CAMI. The initial prerequisite required that the individual be a non-smoker and in healthy condition.

The prospective participant completed a medical history report and cardiovascular disease (CVD) risk factor analysis. The individual then was administered a physical at the CAMI clinic. The physical was equivalent to a Class II Airmen's physical which is regularly administered by CAMI's physicians in order to certify general aviation pilots. This physical consisted of a 12 lead electrocardiogram, pulmonary function test, blood lipid analysis, carbohydrate analysis, hematological review, hearing test, and urinalysis screening.

These results in addition to the results from the medical history and CVD risk factor analysis were then reviewed. If any risks to the individual were detected, he/she was not allowed to participate in the study.

If the individual adequately met these requirements, he/she was given an informed consent to read and sign. This informed consent again presented the individual with the objectives of the study, expectations from them as subjects, and the associated risks and benefits. At this time, and throughout the study, the individuals were encouraged to ask any questions they might have regarding the study.

Table 1. Descriptive Data of subjects involved in the study.

Subject (ID #)	Age (yrs)	Height (inches)	Weight (lbs)	VO2max (ml/kg/min)
Average ± SD	23.6 ± 4.2	67.3 ± 6.3	151.7 ± 34.2	41.4 ± 7.6
Female	22.6 ± 2.4	65.0 ± 3	128.3 ± 20.1	35.8 ± 2.7
Male	25.0 ± 5.9	70.3 ± 1	183.0 ± 20.4	49.0 ± 4.6
F1843	25	61	90	31
F3266	21	64	145	37
F1666	21	65	117	35
F7627	21	64	126	36
F8939	20	66	130	37
F3562	23	68	135	39
F9446	23	70	158	38
F1038	27	62	125	33
M7263	21	70	215	55
M4749	27	71	173	46
M9586	23	72	200	54
M4033	20	70	175	49
M1313	23	69	160	46
M1913	36	70	175	44

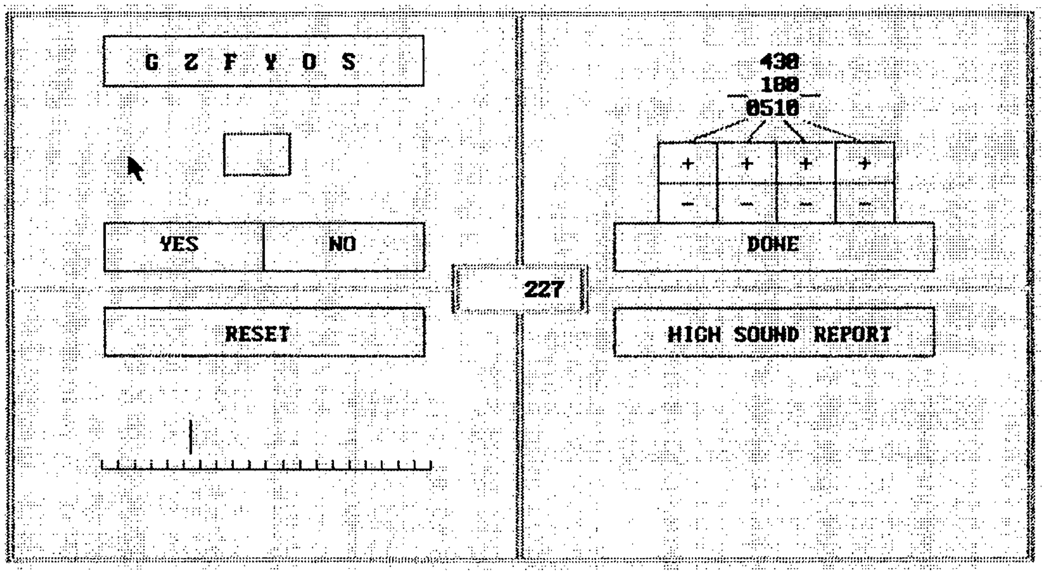
Protocol

In order to make meaningful comparisons of the changes caused by various stressors, it was necessary to use a group of subjects who were similar in their performance capabilities. For this reason, the subject pool for this study was relatively homogeneous. Each subject's age, height, weight, and VO_{2max} are displayed in Table 1. The individual's maximal functional capacity was determined. From this, relative submaximal workloads could be based. Maximal cardiovascular performance characteristics were determined in the Environmental Physiology Laboratory. This test was completed at a minimum of one week prior to the first altitude test.

VO_2max (maximal oxygen consumption) was determined using a cycle ergometer ramp protocol. The subject first began pedaling at low resistance of 30 watts for two minutes. The rpm's were maintained at 60 throughout the warmup and the exercise test. Immediately following this warmup period, the actual test began. According to the ramp protocol, a continuous gradual resistance was applied. The test continued until it voluntarily terminated by the subject or the subject was unable to maintain the 60 rpm pace. During the test, the following physiological variables were monitored and recorded: ventilation, volume of oxygen utilized (VO_2), volume of carbon dioxide produced (VCO_2), heart rate (through a 12 lead ECG monitor), and arterial oxygen saturation (SaO_2).

The SYNWORK1 cognitive function test was used to measure mental ability. SYNWORK1 was developed by the Office of Military Performance Assessment Technology (OMPAT), and it was designed to simulate a generic, complex operational task unlike the traditional performance assessment batteries currently in use. This test consisted of four different mental tasks which were performed simultaneously. Explicit consequences were assigned for the work performed on each of the tasks. Each task was displayed on the PC monitor in a designated quadrant (see figure 1). The Sternberg, six-item memory task was displayed in the upper left quadrant. The three column addition task is located in the upper right quadrant. The lower left quadrant displays a visual monitoring and reset task. The lower right quadrant provides a response window for the auditory monitoring task. A mouse is used to move the cursor to the desired location on the screen for button-press responses. Each individual trial lasted 7.5 minutes. Measures include: accuracy and response latencies of each individual task, a composite score, and cumulative responses as a function of time.

SYNWORK1 Cognitive Performance Task



Individual Task Measurements

Sternberg Short Term Memory
- corrects
- errors
- percent correct
- error latency
- list retrievals

Arithmetic
- corrects
- errors
- percent correct
- correct problem time
- incorrect problem time

Visual Monitoring
- resets
- average reset distance
- average inter-reset time
- lapses

Auditory Monitoring
- pos. & neg. tones
- detection latency
- false alarms
- percent correct
- percent signals detected

Time spent on each measurement task was also recorded.

Figure 1. Image of the SYNWORK1 screen as it appears on the monitor. Variables of interest are also displayed.

The subjects were trained individually on SYNWORK1 before the testing started. Each individual completed six training sessions of 30-45 minutes each. The last two training sessions were conducted in the altitude chamber to practice coordination of the ergometer pedaling exercise with the hand movements required in SYNWORK1 and to familiarize the subject with the altitude chamber. Another reason that this time was allotted was for the learning effects to take place before the individual entered to altitude chamber for the first trial (Liberman, Miles, Nims, & Wesley, 1947). This training was monitored by members of the Environmental Physiology team.

Each subject completed three SYNWORK1 trials during each of the five testing sessions. The first SYNWORK1 trial took place on ground level, the next trial took place three minutes after the designated altitude was reached by the hypobaric chamber, and the third trial took place while engaging in physical activity while at altitude. Each of the five test sessions was performed on separate days at different altitudes. The altitudes at which the trials took place were: ground level; 8,000 feet (8K); 10,000 feet (10K); 12,500 feet (12.5K); and 15,000 feet (15K).

These trials were administered in a randomized fashion. The subject was not informed of the altitude at which he/she would ascend to for the trial. The subject was also not told of the altitude after the flight. These precautions were taken in order to prevent any performance differences due to expectations (Liberman, Miles, Nims, & Wesley, 1947). In this experiment altitude was simulated through the use of the research hypobaric chamber at CAMI. These chamber operators have detailed experience in controlling hypobaric chambers. One operator remained in the chamber at all times as an inside observer.

A consistent protocol was used during each separate trial at the various altitudes. After the subject was brought into the chamber and hooked up to the monitoring sensors, an initial ascent to altitude took place. This "ear and sinus check" was performed to make sure the subject was able to equalize the pressure in his/her ear and sinus passages. The testing was then started. The first part of the procedure called for the subject to complete the General Altitude Questionnaire. During this time, baseline data was recorded. This resting, ground level recording took three minutes. Next, the subject was asked to begin the first of three SYNWORK1 trials. Each of the SYNWORK1 trials last seven and one half minutes. At the end of this trial, a minute and one half of physiological recovery data was recorded. At this point, the gradual ascent to altitude was started. The total time to reach altitude was five minutes for each altitude. This technique was used so that it would take the same amount of time to reach 8,000 feet as it did 15,000 feet, and it would not give the subject an indication of what altitude he/she was being tested. Once at the desired altitude, the individual was again monitored for five minutes for altitude baseline data. After this, the subject was instructed to begin the second SYNWORK1 trial. Recovery data was again recorded upon completion of the SYNWORK1 trial for three and one half minutes. Exercise was then initiated. This transition to exercise lasted for approximately five and one half minutes. The exercise load was set at 40% of the workload attained when VO_{2max} was reached during the stress test. This 40% of VO2max value was used to simulate the possible amount of physical exertion a pilot or aircrew member may have to exert in certain circumstances. A metronome was used to set a pace for the subject at 60 beats per minute. The subject was instructed to make one full crank on the cycle ergometer for each beat. This was done in order to maintain 60 rpm's. At this point, the final SYNWORK1 trial was initiated. Exercise continued for one minute and forty seconds after the SYNWORK1 trial was complete. Another recovery period of five minutes ensued before the descent to ground level was started. The descent also took five minutes. The subject was monitored during the ascent and the descent. The subject again was monitored for recovery data upon completion of the descent for three minutes. During this period, a post-General Altitude Questionnaire was completed (the flight profile can be viewed in Table 2). At this point, the subject was removed from the chamber and observed for approximately fifteen minutes in order to make sure that he/she had recovered without problems. If any ear or sinus blockages occurred during the flight or the subject felt any discomfort, he/she was escorted to the CAMI clinic for a more in depth checkup by one of the physicians. This occurred two times during the study. The ear blocks were only minor and the subjects were given a clean bill of health after being checked by the physician at the CAMI clinic.

Table 2. Flight profile for each altitude simulation.

Stage	Name	Time (seconds)	Time (minutes)
1	Ground level baseline - (questionnaire)	180	3
2	Ground level SYNWORK	450	7.5
3	Ground level recovery	90	1.5
4	Ascent to altitude	300	5
5	Altitude baseline	300	5
6	Altitude SYNWORK	450	7.5
7	Altitude SYNWORK recovery	150	2.5
8	Transition to exercise	330	5.5
9	Exercise SYNWORK1	450	7.5
10	Finish Exercise	180	3
11	Exercise recovery	300	5
12	Descent	300	5
13	Ground level baseline - post (questionnaire)	180	3

The physiological variables which were monitored and recorded during the altitude trials in addition to the SYNWORK1 data included: ventilation, volume of oxygen utilized, volume of carbon dioxide produced, heart rate (through a 12 lead ECG), arterial oxygen saturation, and the partial pressures of oxygen and carbon dioxide of the blood. The material in this thesis deals explicitly with the results from the SYNWORK1 data. Reports regarding this information will be made available through technical reports published by the Civil Aeromedical Institute, Federal Aviation Administration.

Equipment

Various pieces of equipment were used to complete each phase of this experiment. During the stress testing a Sensor Medics 800s cycle ergometer, Sensor Medics metabolic cart model 2900, and ECG machine were used in conjunction with a Quinton automated blood pressure cuff and Nellcor pulse oximeter to monitor the subject. A Hans Rudolph bonnet and face mask apparatus were used with corrugated tubing to capture the exhaled gases of the subject during testing. During the testing in the hypobaric chamber the same Hans Rudolph bonnet and face mask were used with corrugated tubing to capture the exhaled gases of the subject. A Nellcor pulse oximeter, Bosh cycle ergometer, RTS intercom system, Novametrix system 800 PCO_2/PO_2 sensor machine, Marquette Max 6 portable ECG machine, Franz metronome, and a Perkin Elmer breath by breath mass spectrometer were used to complete the chamber testing.

Statistical Procedure

The data from the SYNWORK1 trials (dependent variable) was collected for each subject on each trial. A repeated measures ANOVA model was used to statistically analyze the data. This model was taken from the Myers text (1966) and was set up in a Microsoft Excel environment with the help of Statistical Professors from the University of Oklahoma. The data from each variable was run separately through the model. The ANOVA was double checked by running the same repeated measures test on the same raw data in the SPSS statistical software program. When significant F-values were obtained from the ANOVA, paired t-tests were performed to find the location of the difference (i.e. to find the significantly differently altitude exposures or the significantly different conditions of the SYNWORK1 administration). The t-tests were performed in the SPSS statistical software program. Due to the number of subjects that were able to participate in this study, the statistical procedure included the males and females in one complete group and did not examine gender differences.

CHAPTER IV

Results

The results of the statistical analysis did not indicate significant decreases due to increasing altitude exposure in most instances. Exceptions were the number of arithmetic errors and the arithmetic percent correct. Only data from tests where significant differences were identified will be presented below. Summary tables for the averages and standard deviations of significant variables are displayed in the tables and figures that follow.

Table 3 and figure 2 on page 50 summarize the results from the SYNWORK1 total score variable. There was not a significant difference between the five altitude exposures, but the scores on the altitude & exercise administration of SYNWORK1 were significantly lower than the previous two administrations. A distraction caused by the physical exertion may have been responsible for the decrease in total score.

The response rate, which was the number of mouse clicks per second, was also significantly different during the altitude & exercise administration of SYNWORK1 compared to the previous two administrations. This information can be veiwed on page 51 in table 4 and figure 3. The introduction of exercise slowed the subjects' response rate.

	GL	ALT	ALT_EX
0k	1077 ± 191.6	1083 ± 185.5	1000 ± 185.1**
8k	1037 ± 144.8	1048 ± 176.8	948 ± 218.1**
10k	1059 ± 190.8	1081 ± 158.7	977 ± 138.4**
12.5k	1090 ± 138.7	1023 ± 152.0	957 ± 225.2**
15k	1063 ± 199.0	1052 ± 197.6	954 ± 191.2**

Table 3. Means ± standard deviation for total score during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 1 below. $*p \leq .05$ $**p \leq .01$

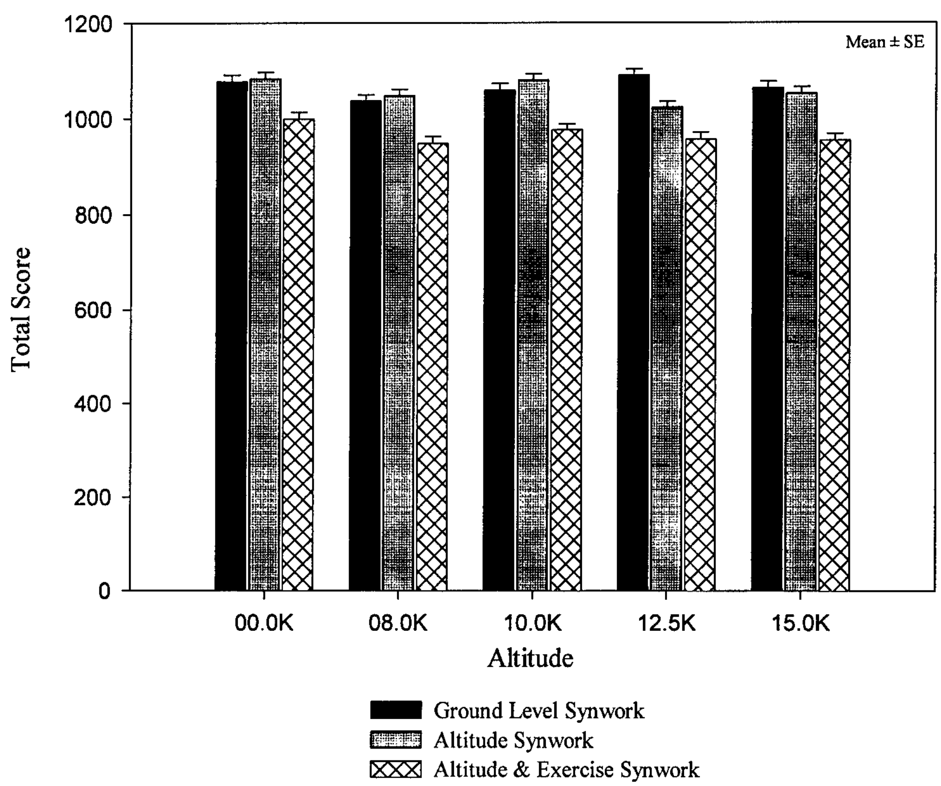


Figure 2. Graph of total score during the three different Synwork1 trails at each of the five different altitudes. The altitude/exercise combination resulted in a significantly lower score. This graph and all others represent Mean ± SE.

	GL	ALT	ALT_EX
0k	1.9 ± 0.4	1.9 ± 0.4	1.7 ± 0.4**
8k	1.8 ± 0.3	1.8 ± 0.3	1.7 ± 0.4**
10k	1.8 ± 0.4	1.8 ± 0.4	1.7 ± 0.4**
12.5k	1.8 ± 0.4	1.8 ± 0.3	1.8 ± 0.4
15k	1.9 ± 0.4	1.9 ± 0.4	1.7 ± 0.4**

Table 4. Means ± standard deviation for the number of responses per second during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 3 below. *$p \leq .05$ **$p \leq .01$

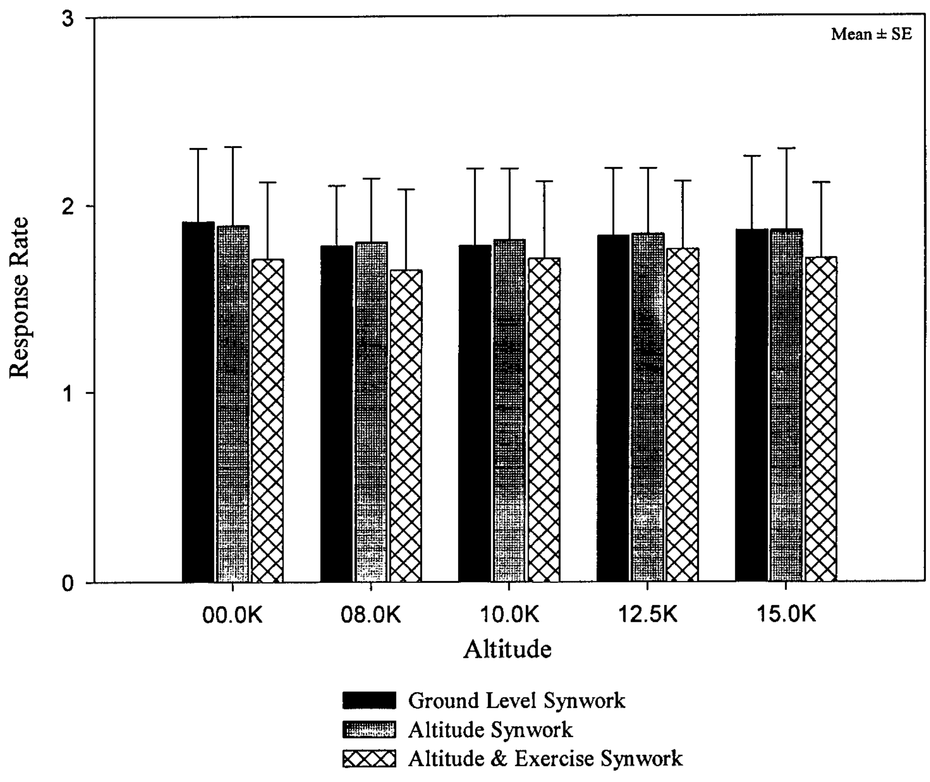


Figure 3. Graph of the number of responses per second during the three different Synwork1 trails at each of the five different altitudes. The altitude/exercise combination resulted in a significantly lower score ($p \leq .01$).

The amount of time taken for each correct arithmetic response significantly increased with exercise compared to the first two SYNWORK1 administrations. These results can be viewed in table 5 and figure 4 on page 53. It is possible that the exercise caused a distraction for the subject and this resulted in an increased amount of time for a correct response.

The percentage of correct arithmetic responses significantly decreased with the introduction of exercise and also with increasing altitude. These results can be viewed on page 54 in table 6 and figure 5. There were significant differences between the ground level and altitude administrations of SYNWORK1 for this variable at the 12.5K level and the 15K level.

The number of correct responses on the arithmetic task were decreased significantly between each administration at each altitude. These results can be viewed in table 7 and figure 6 on page 55. There were not significant differences in this variable with increasing altitude.

	GL	ALT	ALT_EX
0k	7.9 ± 2.8	8.6 ± 3.8	9.6 ± 4.6*
8k	8.6 ± 3.2	8.6 ± 3.1	11.0 ± 7.1*
10k	8.4 ± 3.2	8.3 ± 2.7	9.5 ± 3.6*
12.5k	8.1 ± 2.9	8.5 ± 3.3	9.6 ± 5.6*
15k	8.3 ± 3.4	8.6 ± 3.9	9.4 ± 4.2*

Table 5. Means ± standard deviation for the average amount of time taken for each arithmetic correct response during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 4 below. $*p \leq .05$ $**p \leq .01$

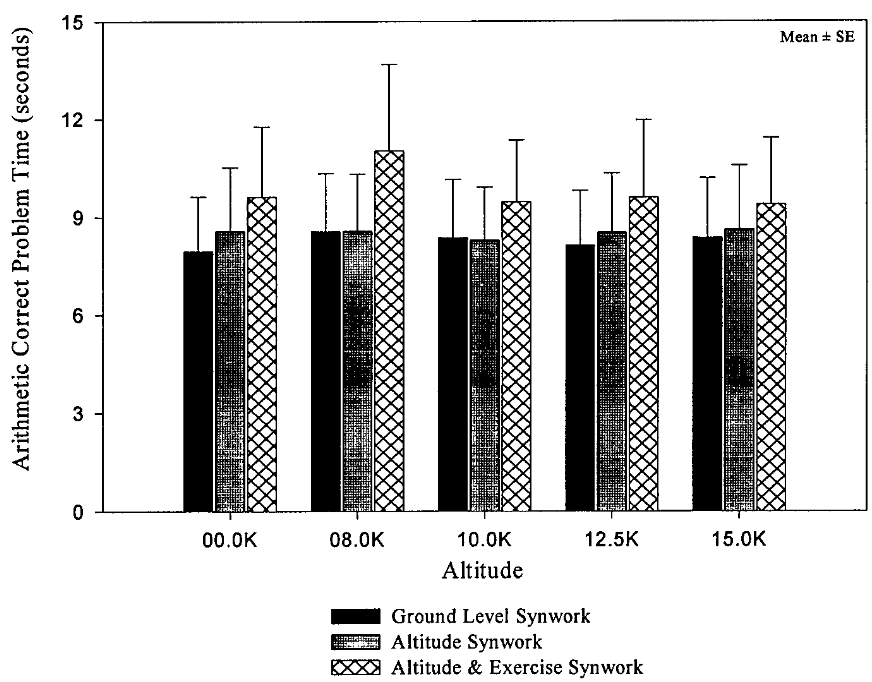


Figure 4. Graph of average amount of time taken for each correct arithmetic response during the three different Synwork1 trails at each of the five different altitudes. The altitude/exercise combination resulted in a significantly increased problem time for correct responses ($p \leq .05$).

	GL	ALT	ALT_EX
0k	92 ± 4	92 ± 5	90 ± 5**
8k	91 ± 4	92 ± 5	91 ± 5
10k	94 ± 3	93 ± 4	90 ± 4**
12.5k	93 ± 3	90 ± 4*	88 ± 8**
15k	91 ± 6	90 ± 5*	85 ± 7**

Table 6. Means ± standard deviation for the percentage of arithmetic problems answered correctly during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 5 below. $^*p \leq .05$ $^{**}p \leq .01$

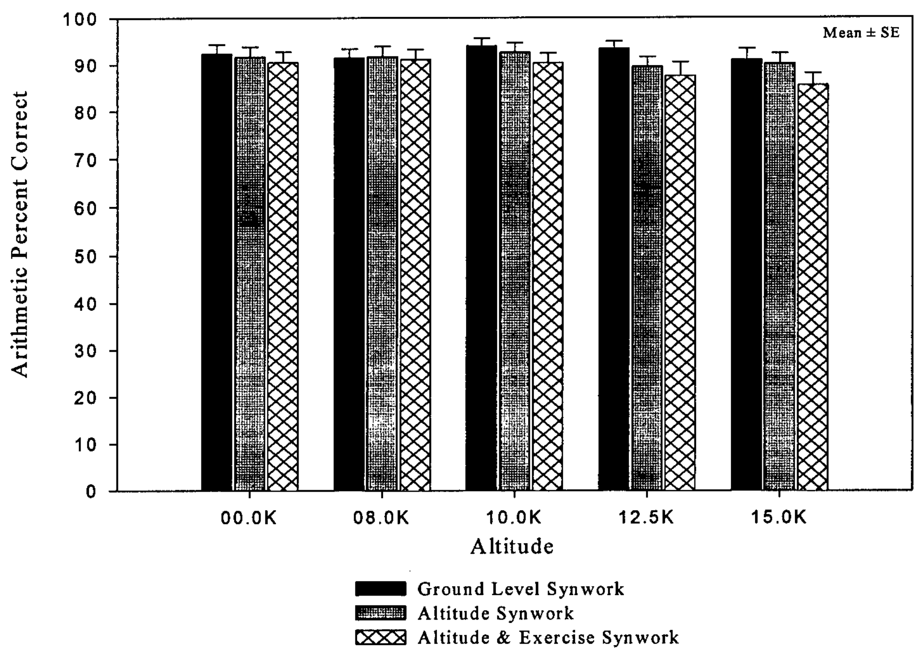


Figure 4. Graph of the percentage of arithmetic problems answered correctly during the three different Synwork1 trails at each of the five different altitudes. The altitude/exercise combination resulted in a significantly lower score ($p \leq .01$). There was also a significant difference between the scores for the following altitudes: 0K - 15K, 8K - 15K, 10K - 12K, 10 - 15K, 12K - 15K ($p \leq .05$).

	GL	ALT	ALT_EX
0k	57 ± 17.3	55 ± 18.4**	49 ± 17.9**
8k	53 ± 14.8	52 ± 14.0*	47 ± 17.5**
10k	56 ± 16.9	54 ± 15.4**	48 ± 15.2**
12.5k	56 ± 14.0	52 ± 14.6**	48 ± 15.7**
15k	55 ± 17.8	54 ± 18.6*	46 ± 17.4**

Table 7. Means ± standard deviation for the number of arithmetic corrects during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 6 below. $*p \leq .05$ $**p \leq .01$

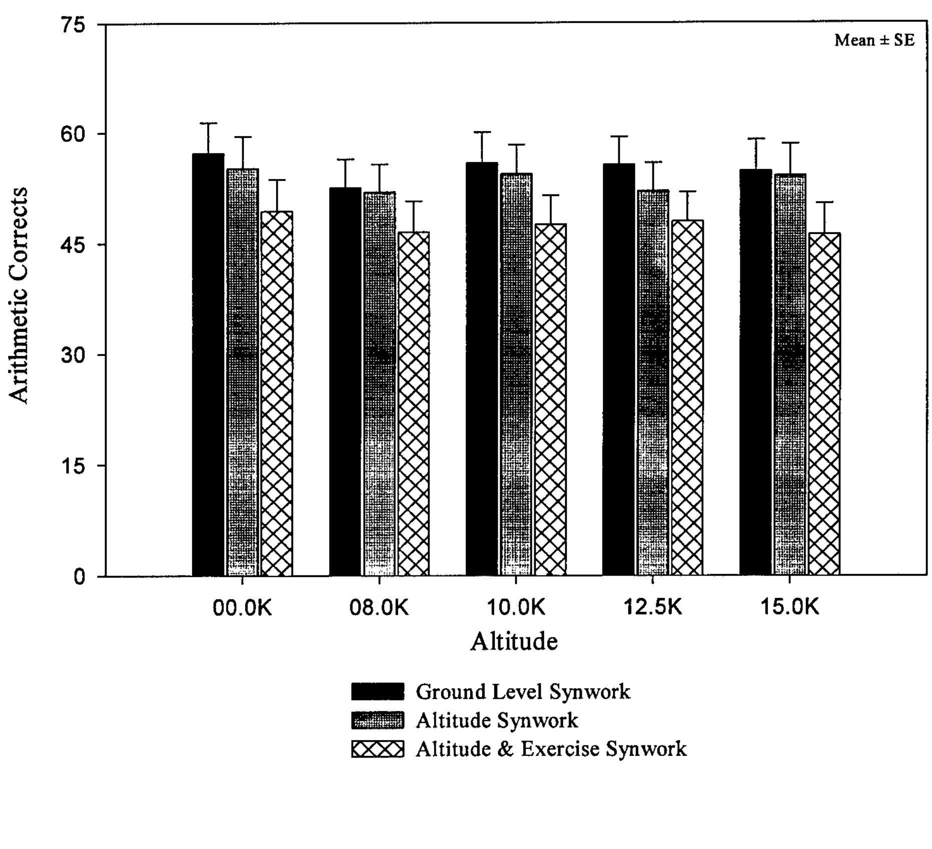


Figure 6. Graph of the number of arithmetic correct responses during the three different Synwork1 trails at each of the five different altitudes. The altitude/exercise combination resulted in a significantly lower score ($p \leq .01$). There were also significant decreases in the number of arithmetic corrects between the ground level and the altitude SYNWORK1 trials ($p \leq .01$).

The number of errors committed on the arithmetic task significantly increased between the three SYNWORK1 administrations at the following altitudes: 10K, 12.5K, and 15K. These results can be viewed in table 8 and figure 6 on page 57. There was also a significant difference between the five altitudes for the this variable. This may suggest that the altitude did have an effect in this case.

The percentage of correct responses on the Sternberg memory task variable decreased significantly with the introduction of exercise. These results can be viewed in table 9 and figure 8 on page 58. It is possible that the distraction caused by the exercise was responsible for this decrease. There were not differences between the altitude exposures.

The number of errors committed on the Sternberg memory task varied greatly between the five different exposures and between the three different SYNWORK1 administrations at each exposure. These results can be viewed on page 59 in table 10 and figure 9.

The number of correct responses on the Sternberg memory task were also varied. These results can be viewed on page 60 in table 11 and figure 10. There was a significant difference between the three SYNWORK1 administrations at each exposure.

	GL	ALT	ALT_EX
0k	4 ± 2.9	4 ± 2.6	3 ± 1.7
8k	4 ± 2.5	4 ± 3.0	3 ± 2.7
10k	3 ± 2.2	4 ± 3.2*	4 ± 2.9**
12.5k	3 ± 2.0	5 ± 3.4*	5 ± 3.9**
15k	4 ± 3.6	5 ± 3.0*	6 ± 3.6**

Table 8. Means ± standard deviation for the number of arithmetic errors committed during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 7 below. *$p \leq .05$ **$p \leq .01$

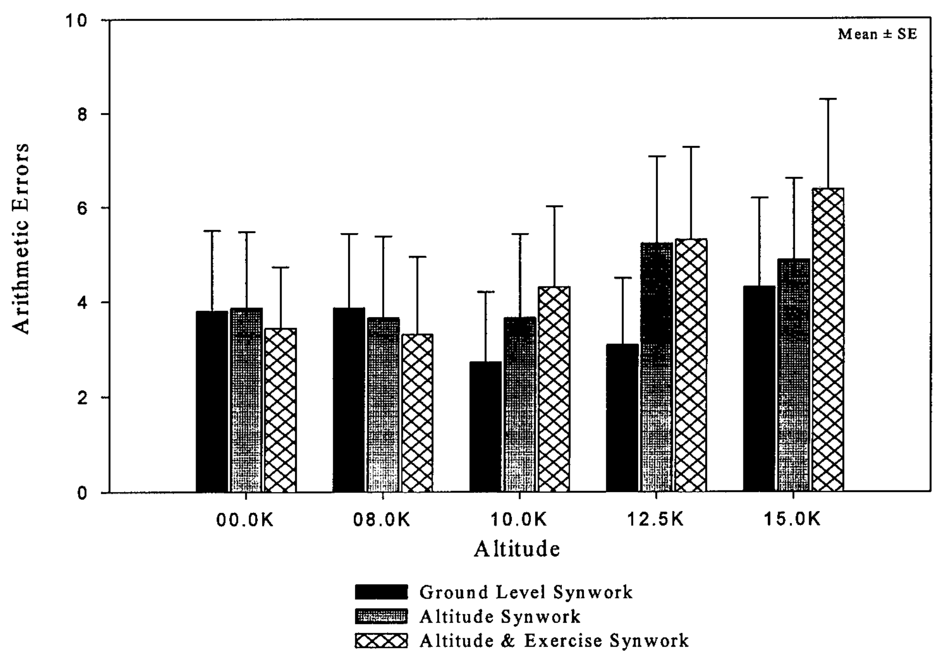


Figure 7. Graph of the number of arithmetic errors committed during the three different Synwork1 trails at each of the five different altitudes. The altitude/exercise combination resulted in a significantly lower score. There were also significant differences between the scores for the following altitudes: 0K - 15K, 8K - 15K, 10K - 12K, 10 - 15K, 12K - 15K ($p \leq .05$). There was a great amount of variation between the scores, as seen in the standard error bars.

	GL	ALT	ALT_EX
0k	86 ± 14.0	92 ± 11.8*	89 ± 12.9*
8k	91 ± 9.3	91 ± 10.2	84 ± 18.8*
10k	84 ± 15.8	94 ± 9.2*	89 ± 9.0*
12.5k	91 ± 10.1	91 ± 8.8	87 ± 16.7*
15k	90 ± 16.7	90 ± 13.4	92 ± 10.5*

Table 9. Means ± standard deviation for the percentage of correct responses on the Sternberg memory task during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 8 below. $^{*}p \leq .05$ $^{**}p \leq .01$

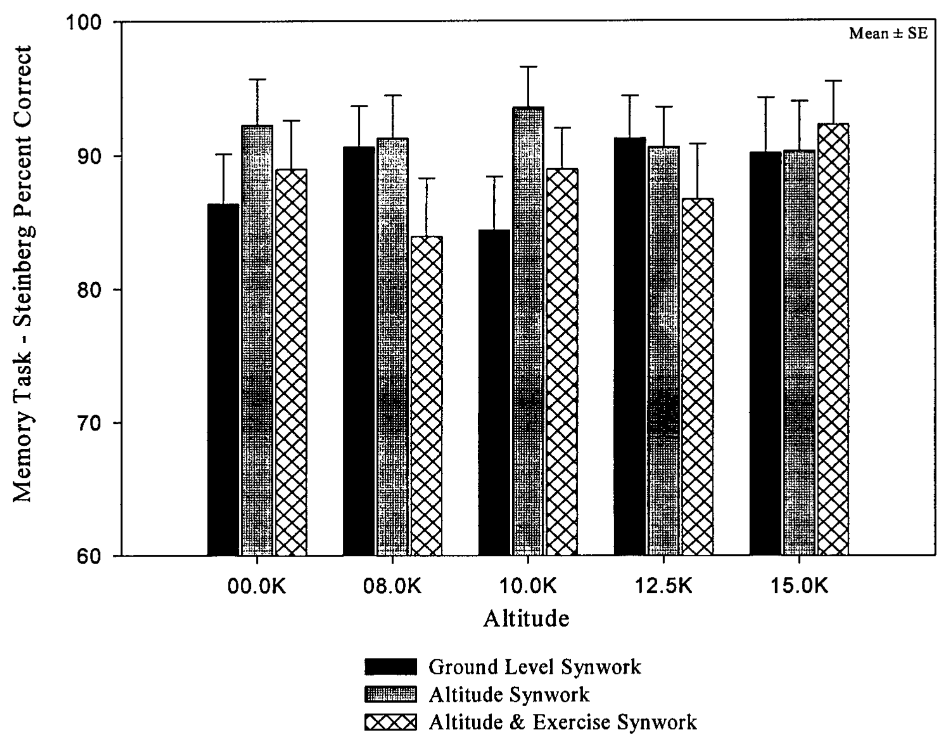


Figure 8. Graph of the percentage of correct response on the Sternberg memory task during the three different Synwork1 trails at each of the five different altitudes. The altitude/exercise combination resulted in a significantly lower score ($p \leq .05$).

	GL	ALT	ALT_EX
0k	3 ± 3.1	2 ± 2.6	2 ± 2.8*
8k	2 ± 2.1	2 ± 2.3	4 ± 4.1*
10k	3 ± 3.5	1 ± 2.0	2 ± 2.0*
12.5k	2 ± 2.2	2 ± 1.9	3 ± 3.7*
15k	2 ± 3.6	2 ± 2.9	2 ± 2.3*

Table 10. Means ± standard deviation for the number of errors committed on the Sternberg memory task during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 9 below. $*p \leq .05$ $**p \leq .01$

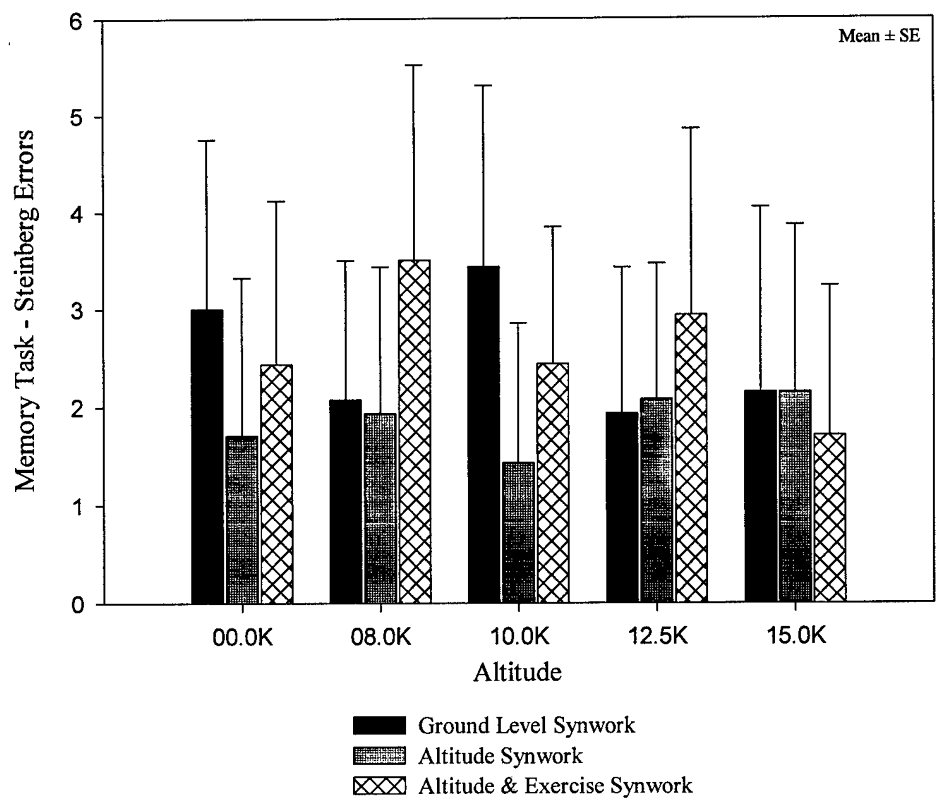


Figure 9. Graph of the number of errors committed on the Sternberg memory task during the three different Synwork1 trails at each of the five different altitudes.

	GL	ALT	ALT_EX
0k	19 ± 3.1	20 ± 2.6	20 ± 2.9
8k	20 ± 2.1	20 ± 2.3	18 ± 4.2*
10k	19 ± 3.5	21 ± 2.0*	20 ± 2.0
12.5k	20 ± 2.3	20 ± 2.0	19 ± 3.7
15k	20 ± 3.8	20 ± 3.0	20 ± 2.33

Table 11. Means ± standard deviation for the number of correct responses on the Sternberg memory task during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 10 below. $^{*}p \leq .05$ $^{**}p \leq .01$

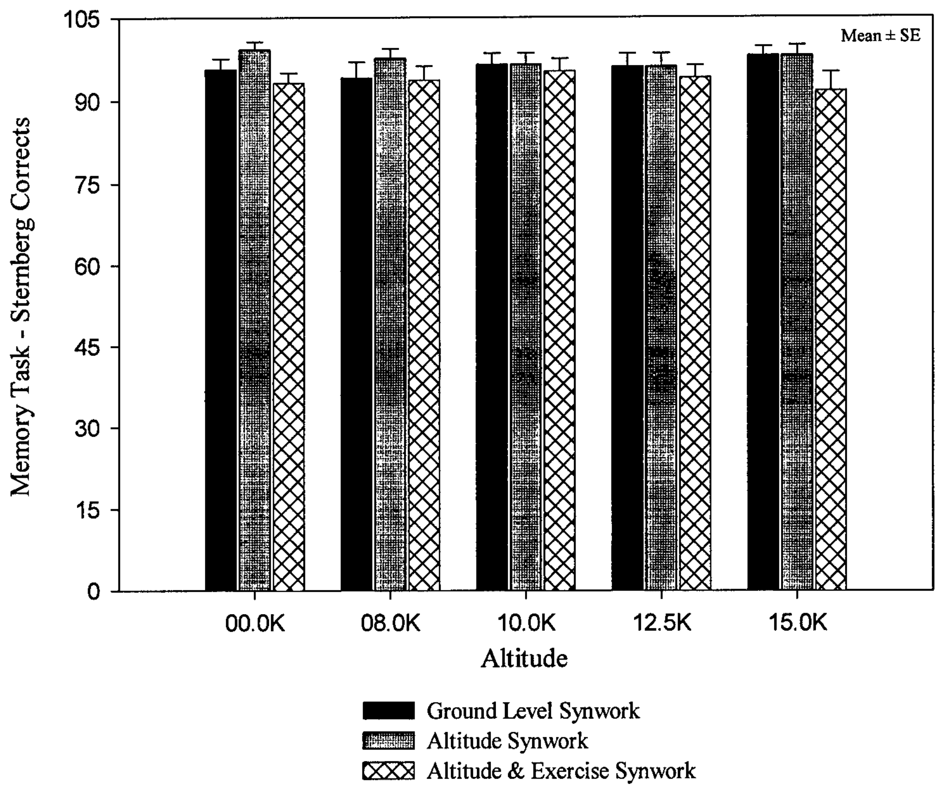


Figure 10. Graph of the number of correct responses on the Sternberg memory task during the three different Synwork1 trails at each of the five different altitudes.

There was a significant interaction between the altitude exposure and the SYNWORK1 administrations for the average distance from the center at reset on the visual monitoring task. These results can be viewed on page 62 in table 12 and figure 9. At the 12.5K level and the 15K level the scores decreased at altitude and were further decreased with the introduction of exercise.

The results of auditory monitoring variable (percentage of tones detected) can be viewed on page 63 in table 13 and figure 12. There was a significant interaction between the altitude exposure and the SYNWORK1 administration. The number of signals detected appeared to decrease with the introduction of exercise but the altitude SYNWORK1 administration was varied between each exposure.

	GL	ALT	ALT_EX
0k	64 ± 17.7	65 ± 17.8	62 ± 18.2
8k	63 ± 20.5	61 ± 20.5	63 ± 21.0
10k	61 ± 19.1	63 ± 20.0	62 ± 20.0
12.5k	63 ± 21.4	61 ± 22.2	59 ± 21.5
15k	65 ± 18.1	63 ± 19.3	62 ± 19.8

Table 12. Means ± standard deviation for the average distance from the center at reset (measured in pixels) on the visual monitoring task during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 11 below.
$^{*}p \leq .05$ $^{**}p \leq .01$

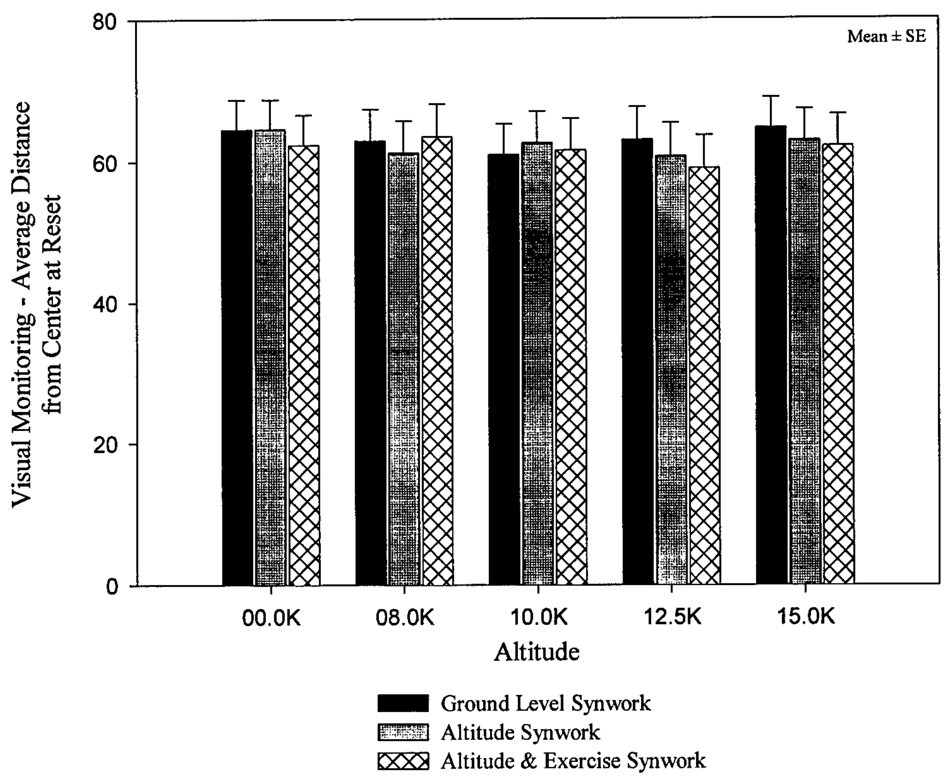


Figure 11. Graph of the number of the average distance from the center at reset (measured in pixels) on the visual monitoring task during the three different Synwork1 trails at each of the five different altitudes. There was a significant interaction between the altitude exposure and the condition in which SYNWORK1 was administered ($p \leq .05$).

	GL	ALT	ALT_EX
0k	96 ± 3.7	99 ± 1.9	93 ± 3.2
8k	94 ± 8.3	98 ± 2.7	94 ± 6.3
10k	96 ± 4.0	96 ± 4.0	95 ± 5.1
12.5k	96 ± 5.7	96 ± 5.7	94 ± 4.9
15k	98 ± 2.7	98 ± 3.4	92 ± 11.3

Table 13. Means ± standard deviation for the percentage of signals detected the on auditory monitoring task during the three different Synwork1 trails at each of the five different altitudes. This data is presented graphically in Figure 12 below. $*p \leq .05$ $**p \leq .01$

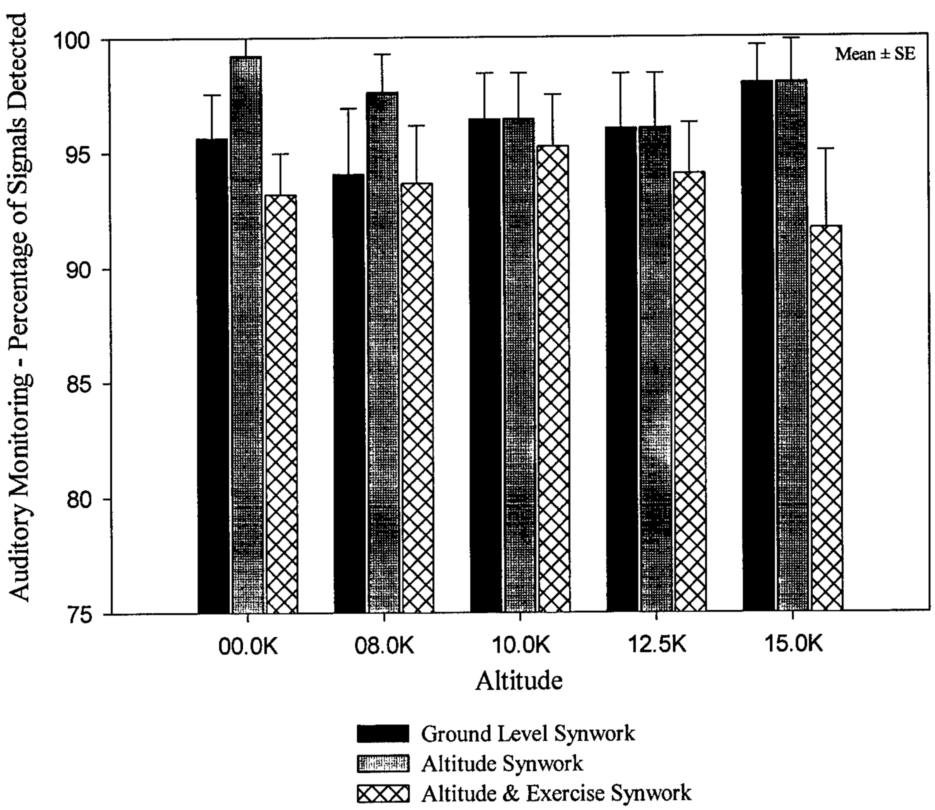


Figure 12. Graph of the number of the percentage of signals detected on the auditory monitoring task during the three different Synwork1 trails at each of the five different altitudes. There was a significant interaction between the altitude exposure and the condition in which SYNWORK1 was administered ($p \leq .05$).

The results of the repeated measures ANOVAs show that there are significant differences between the certain portions of the experiment. Significant F-values were found between the various conditions in which SYNWORK1 was administered to the subject during each testing session. These conditions included a SYNWORK1 administration at ground level, at the specified altitude, and at altitude while engaged in physical activity. The total score, aspects within the memory task, and portions of the arithmetic test showed significant F-values for the conditions in which SYNWORK1 was administered. The response rate of the subjects also indicated a significant F-value, and the t-tests revealed significant differences between the ground level administration and altitude & exercise administration, and between the altitude administration and the altitude & exercise administration. After finding these significant F-values, the next step was to determine where the difference rested between the three conditions in which SYNWORK1 was administered. This was accomplished by running t-tests to compare the three conditions. Of these values, which are also displayed in the tables above, the majority of the differences were found between the non-exercising conditions and the exercising condition.

There were two variables whose results showed a significant F-value for the various altitude exposures.

These variables were the arithmetic errors and the arithmetic percent correct. T-tests were then run to find the location of the differences. The results are displayed in the Tables 3-2 and 3-3. These t-tests indicated significant t-values for the tests between: ground level and 12k, ground level and 15k, 8k and, 8k and 15k, 10k and 12k, and 10k and 15k.

Two other variables indicated a significant F-value for an interaction between altitude and condition of the SYNWORK1 trial (Alt & Ex). This F-value indicates that there is an interaction between the altitude exposure and the condition of the SYNWORK1 administration.

Discussion

It was hypothesized that the majority of the SYNWORK1 tasks would be affected by the increasing altitude levels (as the hypoxic conditions increased). There were not significant differences between the various altitude exposures for the majority of the variables. The two variables which indicated significant differences between certain altitudes were the number of arithmetic errors and the percentage of correct arithmetic answers (see tables 6 and 8 and figures 4 and 6, respectively). These results indicated that there may have been a specificity in the categories of cognitive performance which where affected by the hypoxic conditions. It is possible that an individuals mathematical skills are affected more severely by the ascent to altitude. Kelman, Crow, & Bursill, 1969 suggested that the decrease in cognitive performance due to hypoxic conditions was dependent upon the particular task that the individual was required to perform. It is also possible that the arithmetic problems were more difficult for the subjects of this study compared to the other tasks involved in SYNWORK1. An earlier study suggested that the amount of detriment was dependent upon the difficulty of the task (Noble, Jones, & Davis, 1993). Fiorca, Burr, and Moses (1971) indicated that a simple task was not affected by an altitude of 11,500 feet and suggested that a simple task may not be affected as affected by hypoxic conditions compared to a more difficult task. The study by Cahoon (1972) found that there where greater detriments on a complex test compared a more elementary test in the same hypoxic conditions. It is possible that the subjects' ability to correctly complete arithmetic problems was more significantly affected by the hypoxic conditions.

There are many different possible explanations for why a difference was not seen between the various altitude exposures. The first possible explanation is that the physical condition of the subjects influenced the results. The subjects selected for this study all completed a detailed screening process. This process involved a complete class II airman's physical, a medical history questionnaire, and a stress test on a cycle ergometer. One reason for this screening was to obtain a homogeneous subject pool. This was important in finding valid results and to attempt to eliminate a great number of differences that may have been due to differences between individuals. Another reason for this thorough screening process was to ensure that only healthy subjects were permitted into the experiment. This was done in an attempt to prevent any injuries in the more dangerous, altitude environment (simulated by the hypobaric chamber). This homogeneous subject pool, which was of average to above average cardiovascular fitness levels (see VO_2max values in Table 1) may have reduced possible differences due to altitude because of their fitness levels. If the subjects were in a "healthier" condition, the effects of the hypoxic conditions at higher altitudes may not have affected them to the same degree. In the study by Heckler and Croce (1992), they found that less-fit women took longer to complete a cognitive test and also had greater mistakes on the test compared to a group of more-fit women. They suggested that the fitness level of the individual may have an effect on the mental performance of the individual. It is also possible that an extremely elevated fitness level could cause detriments in performance. Lawler, Powers, and Thompson (1988) studied the effects of hypoxic conditions on more fit and less fit individuals and found that the more fit individuals (marathon runners) experienced greater detriments in their cognitive performance. This suggests that a possible medium exists for optimal resistance to the effects of hypoxia.

Previous studies have found decrements in cognitive performance at similar altitude levels. One reason why these detriments were not seen in this study may be due to the amount of time the subjects were exposed to the hypoxic conditions. In this experiment, the subject was administered the first SYNWORK1 test after five minutes at altitude. The total time spent at the selected altitude was approximately thirty minutes. It is possible that this amount of time was not adequate for the effects of hypoxia to cause significant detriments in cognitive performance. The study by Cahoon (1972) examined the effects of hypoxic conditions after increasing increments of time. He found that the greatest decrements in the individuals' cognitive performance came after three hours of exposure to the hypoxic environment. The results from this study support the current FAR 91.32 that allows aircrew members to stay at altitudes of up to 14,000 feet for up to thirty minutes. The results also suggest that the limit placed on air carrier aviation of 12,500 feet (FAR 121.329 and 135.89) for thirty minutes could be safely matched to the 14,000 level.

Another possible explanation why previous studies have found decrements in performance under similar altitudes is that the exercise in the hypoxic environment may lead to an increased circulation, which offset the decreases which may have been seen. Although the second SYNWORK1 trial was given at the selected condition without exercise, this amount of time spent at the altitude may not have been adequate to cause detriments (as mentioned before). It is possible that the effects may have become evident on the third trial, as more time had been spent at the selected altitude. The study by Higgins et al. (1982) suggested that although there is a decrease in the partial pressure of oxygen with increased altitude, the increase in the heart rate and blood flow which accompany an exercise bout may offset the decreases in the oxygen saturation of the blood. So although the same amount of oxygen is not delivered to the tissues with the same amount of blood, the tissues are exposed to a greater volume of blood. The increase in volume may make up for the decreases in oxygen saturation of the blood.

Yet another explanation for the lack of significant decreases in cognitive performance with increasing altitude is the complexity and familiarity related to the cognitive task. Each subject was trained in five separate sessions prior to his/her first testing session at the selected altitude. Each of the training sessions consisted of 45 minutes of practice on the same test he/she would be given during the testing. It is possible that the subjects gained a familiarity with the test during these training sessions. A study by Denison, Ledwith, and Poulton (1966) examined the effects of two different altitudes on the individuals ability to perform a cognitive task. They found that there were only decrements in performance when the subject was asked to learn and perform a more complicated task under the simulated altitude. They did not find any significant differences when the subjects were familiarized with the test. This is of importance, as a situation in which the pilot is asked to perform a new task may occur in an emergency. Not only training for normal day to day operations but also preparing for possible unusual circumstances could be of great benefit in avoiding performance detriments caused by mild hypoxic conditions.

There were also significant differences in the various conditions in which SYNWORK1 was administered at the selected altitude. The greatest differences were found between the conditions which did not include exercise and the conditions which did include exercise. One explanation for these differences, is that the introduction of a bout of physical exertion distracted the subject and caused him/her to score lower on the cognitive function test. The study by Fowler, Porlier, Elcombe, and Taylor (1985) showed that the reaction times of an individual were not affected when only hypoxic conditions were introduced. The reaction times were decreased when the subject was required to complete a bout of physical exertion at the same time. They suggested that the distraction of the exercise caused the detriment in performance. Tomporowski and Ellis (1986) suggested that the effects of exercise on cognitive performance depend on the intensity of the exercise, the duration of the exercise, and the fitness level of the individual. As an individual starts to exercise and continues this exercise, the oxygen saturation of the blood may decrease to a certain extent. A normal resting level for SaO_2 is approximatey 98%. During exercise at sea level it may drop to 95%. The amount of the decrease depends greatly on the physical condition, health status (presence or absence of disease and smoker or non-smoker), and nutritional status of the individual. There is a decrease in SaO_2 at altitude due to the decreased partial pressure of O_2 in the atmosphere. There is a further decrease in SaO_2 in an individual when he/she exercises. It is possible that this increased drop in SaO_2 lead to further decrements in cognitive performance. This possibility will be further examined in data analysis presented in FAA reports concerning this study.

There is no argument that when an individual ascends to high altitudes, the individual will at some point experience adverse effects from hypoxic hypoxia. Cognitive performance will be one of the first areas affected by the conditions. This experiment examined the effects of various altitude exposures combined with different treatment conditions on an individual's cognitive ability. This cognitive ability was measured through the use of the SYNWORK1 test battery. This test battery simulated four different tasks which may be similar to duties required of a pilot or an aircrew member during a flight. A bout of exercise was imposed on the subject during the final test administration at each altitude to simulate the possible physical exertion that an individual may be required to complete in the aviation environment. The purpose of the testing was to attempt to identify the level at which the hypoxic conditions of increasing altitude begin to affect the pilots and/or aircrew of unpressurized aircraft. In addition to the altitude a bout of physical activity was introduced to simulate a possible level of exertion that may be required of the aircrew members. From the results, it is possible that higher levels of physical fitness and increased training of the mental tasks associated with the flight deck may reduce the detrimental effects caused by hypoxic conditions. The results also supported the notion that the detrimental effects may not become evident if the time spent in the hypoxic conditions is limited to 30 minutes or less. The introduction of a bout of physical exertion during the cognitive function test did cause differences in performance. This knowledge could be of great use for pilots and aircrew members as any one of them could be exposed to an emergency situation during any flight where a greater amount of physical exertion was necessary to maneuver the aircraft. An understanding that activity may lead to a greater risk for the detrimental effects caused by a hypoxic environment are very valuable. Further research may examine these factors in order to gain knowledge which may better explain the effects of hypoxia combined with physical exertion.

CHAPTER V

Conclusions and Recommendations

The purpose of this study was to examine the relationships between five different altitude exposures and cognitive performance and to examine the possible effects of physical activity at each altitude on cognitive performance. The following conclusions can be stated:

1. The introduction of physical activity while administering the SYNWORK1 test significantly decreased cognitive performance in many areas.
2. The altitude exposure did show significant detriments in performance in two areas of the arithmetic task: the percentage of correct answers and the number of errors.
3. Although there were not significant detriments caused by increasing altitude exposure with the exception of two variables, trends for decreased performance became evident at the 10,000 foot level and above.
4. The SaO2 data indicated the decreases in oxyhemaglobin saturation with increased altitude and showed further decreases with the onset of exercise.

Recommendations

1. Another study examining longer durations spent in various hypoxic conditions may indicate the possible significance of this factor in causing significant detriments in cognitive performance.
2. An investigation examining higher intensities of physical activity may also be beneficial in determining the magnitude of the detriments caused by the introduction of exercise.
3. A similar study with a higher n (number of subjects) may equalize some of the variation caused by differences between subjects and indicate whether or not trends seen in this study were significant.

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Appendix A

Variable Description and Raw Data

SYNWORK1 Variable Descriptions

Column Heading	Description
tot_scor	composite score
resp_rat	response rate (responses per second)
s_corr	Sternberg corrects
s_errors	Sternberg errors
s_pcorr	Sternberg percent correct
s_corr_l	Sternberg correct latency
s_err_l	Sternberg error latency
s_list_r	Sternberg list retrievals
a_corr	Arithmetic corrects
a_err	Arithmetic errors
a_pcorr	Arithmetic percent correct
a_corrpt	Arithmetic correct problem time
a_incr_p	Arithmetic incorrect problem time
v_rsts	Visual monitoring resets
v_adfcrt	Visual monitoring average distance from center at reset
v_ai_rt	Visual monitoring average inter-reset time
v_lapses	Visual monitoring lapses
am_ptd	Auditory monitoring positive tone detections
am_fa	Auditory monitoring false alarms
am_pcor	Auditory monitoring percent correct
am_psd	Auditory monitoring percent signals detected
am_dl	Auditory monitoring detection latency

SYNWORK1 Raw Data

SUBJECT	ALT	TMT	GENDER	TOT SCOR	RESP RAT	S CORR	S ERRORS	S PCORR	S CORR L	S ERR L	S LIST R	A CORR	A ERR	A PCORR	A CORRPT	A INCR P
1038	1	1	2	1117	1.83	20	2	90.91	3.37	5.00	.00	57.00	2.00	95.00	7.43	5.45
1038	1	2	2	1197	1.85	20	2	90.91	3.56	5.92	.00	62.00	.00	98.41	7.05	.00
1038	1	3	2	1072	1.81	21	1	95.45	3.10	2.20	.00	52.00	3.00	92.86	7.89	7.43
1038	2	1	2	1160	1.82	21	1	95.45	2.63	2.34	.00	57.00	1.00	96.61	7.58	6.71
1038	2	2	2	1194	1.88	21	1	95.45	2.87	4.71	.00	60.00	.00	98.36	7.23	.00
1038	2	3	2	1117	1.83	21	1	95.45	2.46	2.18	.00	57.00	3.00	93.44	7.34	6.20
1038	3	1	2	1075	1.40	22	0	100.00	2.24	.00	.00	48.00	1.00	96.00	9.07	.00
1038	3	2	2	1074	1.72	22	0	100.00	3.20	.00	.00	49.00	2.00	94.23	8.49	9.85
1038	3	3	2	1017	1.66	19	3	86.36	2.82	3.21	.00	48.00	2.00	94.12	8.58	11.42
1038	4	1	2	1198	1.75	22	0	100.00	2.60	.00	.00	58.00	.00	98.31	7.56	.00
1038	4	2	2	1146	1.80	22	0	100.00	2.76	.00	.00	54.00	1.00	96.43	7.87	11.01
1038	4	3	2	1166	1.82	20	2	90.91	2.94	3.01	.00	59.00	.00	98.33	7.35	.00
1038	5	1	2	1158	1.83	22	0	100.00	2.43	.00	.00	55.00	1.00	96.49	7.75	7.64
1038	5	2	2	1190	1.83	22	0	100.00	2.50	.00	.00	59.00	2.00	95.16	7.16	8.25
1038	5	3	2	1036	1.85	18	4	81.82	2.48	3.55	.00	54.00	2.00	94.74	7.64	11.02
1666	1	1	2	1121	1.93	22	0	100.00	3.31	.00	.00	57.00	7.00	87.69	6.81	8.14
1666	1	2	2	1210	1.99	22	0	100.00	3.67	.00	.00	66.00	3.00	94.29	6.47	6.05
1666	1	3	2	929	1.46	20	2	90.91	3.56	2.69	1.00	42.00	4.00	89.36	9.19	13.38
1666	2	1	2	1089	1.94	21	1	95.45	3.54	3.61	.00	59.00	6.00	89.39	6.70	7.30
1666	2	2	2	1090	1.79	21	1	95.45	3.01	2.96	.00	57.00	7.00	87.69	6.75	7.83
1666	2	3	2	988	1.67	22	0	100.00	3.82	.00	.00	47.00	5.00	88.68	8.69	6.26
1666	3	1	2	1214	1.87	21	1	95.45	2.07	1.21	.00	65.00	4.00	92.86	6.38	6.20
1666	3	2	2	1130	1.95	21	1	95.45	3.10	2.09	.00	60.00	7.00	88.24	6.64	6.51
1666	3	3	2	835	1.37	19	3	86.36	3.18	3.61	1.00	39.00	7.00	82.98	9.87	7.58
1666	4	1	2	1173	1.80	22	0	100.00	3.51	.00	.00	60.00	3.00	93.75	6.85	7.34
1666	4	2	2	1031	1.90	22	0	100.00	2.97	.00	.00	53.00	8.00	85.48	7.12	7.52
1666	4	3	2	852	1.62	21	1	95.45	3.72	3.96	.00	39.00	10.00	78.00	8.55	9.33
1666	5	1	2	1303	1.98	22	0	100.00	2.45	.00	.00	71.00	2.00	95.95	5.97	6.68
1666	5	2	2	1269	2.23	22	0	100.00	2.33	.00	.00	72.00	6.00	91.14	5.63	5.68
1666	5	3	2	950	1.70	21	1	95.45	3.16	3.83	.00	46.00	9.00	82.14	8.10	6.83
1843	1	1	2	1027	1.32	22	0	100.00	3.06	.00	.00	42.00	.00	97.67	10.39	.00
1843	1	2	2	1019	1.30	22	0	100.00	2.69	.00	.00	40.00	.00	97.56	10.94	.00
1843	1	3	2	892	1.21	20	2	90.91	2.36	3.76	.00	35.00	2.00	92.11	11.74	12.53
1843	2	1	2	949	1.27	22	0	100.00	2.29	.00	.00	35.00	2.00	92.11	11.62	13.04
1843	2	2	2	1041	1.35	22	0	100.00	2.65	.00	.00	43.00	.00	97.73	10.17	.00
1843	2	3	2	979	1.33	22	0	100.00	2.71	.00	.00	38.00	.00	97.44	11.68	.00
1843	3	1	2	979	1.15	22	0	100.00	2.51	.00	.00	36.00	.00	97.30	11.98	.00
1843	3	2	2	952	1.26	22	0	100.00	2.67	.00	.00	34.00	.00	97.14	12.78	.00
1843	3	3	2	938	1.23	22	0	100.00	2.45	.00	.00	36.00	2.00	92.31	11.61	10.14
1843	4	1	2	1030	1.35	22	0	100.00	2.95	.00	.00	42.00	1.00	95.45	10.05	12.43
1843	4	2	2	928	1.39	20	2	90.91	2.65	4.61	.00	37.00	2.00	92.50	11.13	11.44
1843	4	3	2	1015	1.34	22	0	100.00	2.97	.00	.00	42.00	1.00	95.45	10.36	7.64
1843	5	1	2	1007	1.39	22	0	100.00	3.38	.00	.00	39.00	.00	97.50	11.26	.00
1843	5	2	2	1040	1.38	21	1	95.45	2.65	3.10	.00	44.00	.00	97.78	9.93	.00
1843	5	3	2	973	1.26	22	0	100.00	3.03	.00	.00	37.00	.00	97.37	11.69	.00
3266	1	1	2	1038	1.96	17	5	77.27	2.65	3.04	.00	58.00	5.00	90.63	6.85	7.97
3266	1	2	2	1142	1.98	19	3	86.36	2.56	2.45	.00	65.00	5.00	91.55	6.13	7.62
3266	1	3	2	1026	1.90	16	6	72.73	2.53	3.99	.00	59.00	4.00	92.19	6.86	8.43
3266	2	1	2	1035	1.66	21	1	95.45	2.21	2.20	.00	51.00	6.00	87.93	7.41	9.40
3266	2	2	2	1064	1.76	19	3	86.36	2.30	2.41	.00	54.00	2.00	94.74	7.74	9.94
3266	2	3	2	897	1.60	13	9	59.09	2.43	2.44	.00	48.00	2.00	94.12	8.71	8.58
3266	3	1	2	854	1.79	10	12	45.45	2.36	3.10	.00	55.00	5.00	90.16	6.82	8.51
3266	3	2	2	1102	1.81	21	1	95.45	2.04	2.09	.00	54.00	3.00	93.10	7.68	6.89
3266	3	3	2	999	1.68	17	5	77.27	1.73	1.65	.00	54.00	5.00	90.00	7.29	8.45
3266	4	1	2	1078	1.73	18	4	81.82	1.87	2.70	.00	57.00	3.00	93.44	7.26	8.56
3266	4	2	2	1057	1.80	16	6	72.73	2.31	2.43	.00	60.00	4.00	92.31	6.89	6.24
3266	4	3	2	1015	1.75	22	0	100.00	2.21	.00	.00	50.00	9.00	83.33	7.33	8.05
3266	5	1	2	803	1.69	12	9	57.14	3.61	4.81	.00	46.00	7.00	85.19	8.32	7.00
3266	5	2	2	1048	1.92	18	4	81.82	2.74	2.97	.00	57.00	6.00	89.06	6.78	8.31
3266	5	3	2	874	1.84	17	5	77.27	2.93	2.17	.00	48.00	12.00	78.69	7.55	6.13
3562	1	1	2	974	1.97	12	10	54.55	3.95	4.34	.00	61.00	3.00	93.85	6.84	6.73
3562	1	2	2	983	1.83	20	2	90.91	4.13	4.64	.00	46.00	5.00	88.46	8.66	7.48
3562	1	3	2	928	1.72	22	0	100.00	4.09	.00	.00	43.00	8.00	82.69	8.71	7.46
3562	2	1	2	1112	1.72	22	0	100.00	3.42	.00	.00	55.00	4.00	91.67	7.37	7.57
3562	2	2	2	786	1.73	16	6	72.73	3.43	4.46	.00	41.00	10.00	78.85	8.26	7.50
3562	2	3	2	494	.73	11	10	52.38	6.39	6.44	.00	10.00	1.00	83.33	32.63	29.99
3562	3	1	2	1097	1.85	18	4	81.82	3.37	4.91	.00	58.00	2.00	95.08	7.16	9.24
3562	3	2	2	1019	1.69	20	2	90.91	3.80	3.43	.00	51.00	5.00	89.47	7.57	7.64
3562	3	3	2	1127	2.03	22	0	100.00	3.63	.00	.00	57.00	5.00	90.48	7.06	6.66
3562	4	1	2	1098	1.74	21	1	95.45	4.21	4.66	.00	55.00	4.00	91.67	7.30	7.97
3562	4	2	2	937	1.83	19	3	86.36	4.58	5.17	1.00	46.00	6.00	86.79	8.29	9.76
3562	4	3	2	540	1.43	12	10	54.55	5.29	5.67	.00	27.00	12.00	67.50	10.15	11.99
3562	5	1	2	1115	1.85	21	1	95.45	2.92	5.87	.00	58.00	5.00	90.63	6.94	6.44
3562	5	2	2	895	1.64	20	2	90.91	4.39	4.65	.00	39.00	7.00	82.98	9.66	8.17
3562	5	3	2	733	1.48	19	1	95.00	3.14	5.75	.00	31.00	8.00	77.50	8.83	9.12
7627	1	1	2	977	1.76	19	3	86.36	4.20	3.92	2.00	47.00	2.00	94.00	8.94	7.84
7627	1	2	2	1006	1.86	22	0	100.00	3.73	.00	.00	44.00	4.00	89.80	8.99	10.07
7627	1	3	2	838	1.54	18	4	81.82	3.90	2.60	1.00	36.00	4.00	87.80	10.53	12.56
7627	2	1	2	1004	1.72	22	0	100.00	3.73	.00	1.00	46.00	.00	97.87	9.37	.00
7627	2	2	2	1033	1.88	22	0	100.00	4.42	.00	.00	45.00	3.00	91.84	9.19	8.45
7627	2	3	2	800	1.63	20	2	90.91	3.27	1.56	1.00	38.00	5.00	86.36	10.16	10.18
7627	3	1	2	911	1.61	20	2	90.91	3.34	4.63	1.00	44.00	3.00	91.67	9.18	9.81
7627	3	2	2	994	1.58	20	2	90.91	3.26	2.81	.00	45.00	1.00	95.74	9.31	11.20
7627	3	3	2	795	1.62	20	2	90.91	3.94	5.84	1.00	32.00	5.00	84.21	11.90	10.94
7627	4	1	2	1052	1.73	22	0	100.00	4.28	.00	.00	49.00	2.00	94.23	8.49	8.79
7627	4	2	2	1031	1.61	21	1	95.45	3.77	4.45	.00	49.00	1.00	96.08	8.77	5.47
7627	4	3	2	1099	1.87	21	1	95.45	3.20	1.81	.00	52.00	.00	98.11	8.36	.00
7627	5	1	2	1073	1.85	22	0	100.00	4.48	.00	.00	47.00	1.00	95.92	9.02	8.40
7627	5	2	2	975	1.56	22	0	100.00	3.94	.00	.00	42.00	3.00	91.30	9.96	5.05
7627	5	3	2	957	1.66	22	0	100.00	4.72	.00	.00	40.00	5.00	86.96	9.28	12.89
8939	1	1	2	1546	2.80	21	1	95.45	3.53	2.63	.00	97.00	2.00	97.00	4.43	4.65
8939	1	2	2	1456	2.61	21	1	95.45	3.04	3.42	.00	93.00	5.00	93.94	4.45	4.61
8939	1	3	2	1388	2.54	20	2	90.91	3.07	2.81	.00	86.00	4.00	94.51	4.78	6.07
8939	2	1	2	1210	2.30	21	1	95.45	3.53	2.20	.00	70.00	8.00	88.61	5.53	6.46
8939	2	2	2	1226	2.35	22	0	100.00	3.58	.00	.00	68.00	7.00	89.47	5.70	7.15
8939	2	3	2	1240	2.33	22	0	100.00	2.87	.00	.00	72.00	8.00	88.89	5.41	6.23
8939	3	1	2	1388	2.61	21	1	95.45	3.54	3.73	.00	86.00	6.00	92.47	4.78	4.77
8939	3	2	2	1470	2.50	22	0	100.00	2.87	.00	.00	91.00	4.00	94.79	4.51	7.12
8939	3	3	2	1241	2.61	18	4	81.82	3.49	2.08	.00	83.00	10.00	88.30	4.74	4.59
8939	4	1	2	1156	1.95	18	3	85.71	2.93	3.88	.00	65.00	5.00	91.55	6.03	7.05
8939	4	2	2	1064	2.25	18	4	81.82	2.79	3.06	.00	64.00	10.00	85.33	5.87	6.34
8939	4	3	2	1054	2.13	20	2	90.91	2.95	3.60	.00	60.00	10.00	84.51	6.18	6.46
8939	5	1	2	1354	2.68	20	2	90.91	3.39	1.88	.00	89.00	10.00	89.00	4.35	5.01
8939	5	2	2	1479	2.68	22	0	100.00	3.03	.00	.00	93.00	7.00	92.08	4.35	4.59
8939	5	3	2	1397	2.58	20	2	90.91	2.78	2.57	.00	90.00	8.00	90.91	4.46	4.20
9446	1	1	2	829	1.147	22	0	100	2.62	0	0	28	0	96.55	15.36	0
9446	1	2	2	808	1.027	21	1	95.45	2.82	3.11	0	25	0	96.15	17.1	0
9446	1	3	2	685	0.884	21	1	95.45	2.15	3.31	0	17	3	80.95	22.41	16.76

SYNWORK1 Raw Data

9446	2	1	2	798	1.169	21	1	95.45	2.78	1.63	0	27	2	90	15.22	10.76
9446	2	2	2	724	0.987	21	1	95.45	2.67	2.74	0	23	2	88.46	17.03	18.6
9446	2	3	2	809	0.842	22	0	100	2.25	0	0	21	1	91.3	19.85	20.65
9446	3	1	2	810	1.109	19	3	86.36	3	2.95	0	31	0	96.88	14.07	0
9446	3	2	2	840	1.067	22	0	100	2.62	0	0	32	1	94.12	13.3	11.18
9446	3	3	2	750	0.911	21	1	95.45	2.89	3.47	0	23	0	95.83	18.7	0
9446	4	1	2	900	1.042	22	0	100	2.86	0	0	32	0	96.97	13.57	0
9446	4	2	2	760	0.978	21	1	95.45	3.01	1.6	0	23	2	88.46	17.25	16.97
9446	4	3	2	588	0.836	19	3	86.36	2.9	3.99	0	15	1	88.24	28.07	15.6
9446	5	1	2	850	1.073	22	0	100	2.81	0	0	28	1	93.33	15.04	13.92
9446	5	2	2	847	1.078	21	1	95.45	3.11	6.01	0	26	0	96.3	16.81	0
9446	5	3	2	726	0.881	22	0	100	2.72	0	0	17	4	77.27	21.03	15.91
1913	1	1	1	721	1.79	14	8	63.64	3.42	3.92	.00	32.00	4.00	86.49	12.16	12.07
1913	1	2	1	704	1.34	18	4	81.82	3.19	2.81	.00	21.00	4.00	80.77	17.00	18.55
1913	1	3	1	748	1.23	21	1	95.45	2.04	2.83	.00	21.00	4.00	80.77	17.25	16.30
1913	2	1	1	743	1.49	18	4	81.82	2.49	2.85	.00	25.00	2.00	89.29	15.74	20.34
1913	2	2	1	737	1.53	15	7	68.18	2.24	2.06	.00	29.00	2.00	90.63	13.77	18.58
1913	2	3	1	650	1.52	11	11	50.00	3.24	2.17	.00	27.00	2.00	90.00	14.75	17.16
1913	3	1	1	736	1.35	15	7	68.18	2.43	1.97	.00	27.00	1.00	93.10	15.71	9.13
1913	3	2	1	853	1.44	16	6	72.73	2.40	3.39	.00	35.00	.00	97.22	12.49	.00
1913	3	3	1	837	1.25	20	2	90.91	2.30	1.78	.00	28.00	1.00	93.33	14.34	31.61
1913	4	1	1	780	1.57	18	4	81.82	2.87	4.25	.00	27.00	2.00	90.00	15.30	11.82
1913	4	2	1	776	1.67	17	5	77.27	2.88	4.47	.00	29.00	2.00	90.63	14.13	11.59
1913	4	3	1	575	1.57	11	11	50.00	2.54	3.20	.00	24.00	6.00	77.42	14.69	13.29
1913	5	1	1	659	1.38	18	4	81.82	2.46	2.51	.00	21.00	5.00	77.78	16.06	19.85
1913	5	2	1	694	1.24	17	5	77.27	2.13	2.56	.00	21.00	3.00	84.00	17.59	20.69
1913	5	3	1	603	1.17	14	8	63.64	2.61	1.70	.00	20.00	4.00	80.00	16.15	18.43
4749	1	1	1	1347	2.27	21	1	95.45	2.95	3.00	.00	78.00	2.00	96.30	5.49	5.12
4749	1	2	1	1323	2.44	22	0	100.00	4.08	.00	.00	74.00	3.00	94.87	5.74	4.22
4749	1	3	1	1287	2.04	22	0	100.00	2.67	.00	.00	69.00	1.00	97.18	6.26	4.80
4749	2	1	1	1282	2.31	18	4	81.82	2.76	3.60	.00	78.00	3.00	95.12	5.39	5.23
4749	2	2	1	1348	2.26	22	0	100.00	3.49	.00	.00	76.00	3.00	95.00	5.47	6.84
4749	2	3	1	1268	2.12	20	2	90.91	1.93	2.48	.00	72.00	2.00	96.00	5.90	6.01
4749	3	1	1	1365	2.28	22	0	100.00	3.49	.00	.00	79.00	3.00	95.18	5.41	3.83
4749	3	2	1	1313	2.36	22	0	100.00	3.70	.00	.00	73.00	2.00	96.05	5.86	5.76
4749	3	3	1	1121	1.98	22	0	100.00	3.24	.00	.00	57.00	4.00	91.94	6.99	10.36
4749	4	1	1	1346	2.48	22	0	100.00	3.59	.00	.00	78.00	5.00	92.86	5.29	5.43
4749	4	2	1	1375	2.30	22	0	100.00	2.46	.00	.00	81.00	4.00	94.19	5.06	6.67
4749	4	3	1	1268	2.20	21	1	95.45	3.41	5.57	.00	71.00	2.00	95.95	5.99	5.29
4749	5	1	1	1390	2.31	21	1	95.45	2.98	2.83	.00	80.00	1.00	97.56	5.39	5.00
4749	5	2	1	1299	2.34	22	0	100.00	3.80	.00	.00	74.00	5.00	92.50	5.55	5.72
4749	5	3	1	1207	2.02	22	0	100.00	3.25	.00	.00	64.00	4.00	92.75	6.39	6.39
7263	1	1	1	1137	2.34	16	6	72.73	2.97	2.94	.00	74.00	10.00	87.06	5.20	5.44
7263	1	2	1	994	2.32	12	10	54.55	4.01	4.16	.00	68.00	10.00	86.08	5.68	5.37
7263	1	3	1	930	2.05	11	11	50.00	3.38	4.08	.00	63.00	5.00	91.30	6.41	6.43
7263	2	1	1	1118	1.88	16	6	72.73	2.47	2.59	.00	67.00	4.00	93.06	6.09	7.39
7263	2	2	1	1117	2.00	18	4	81.82	2.98	3.57	.00	61.00	3.00	93.85	6.80	7.57
7263	2	3	1	802	1.89	13	9	59.09	2.30	2.46	.00	52.00	10.00	82.54	6.81	8.11
7263	3	1	1	1133	2.07	16	6	72.73	3.17	2.78	.00	69.00	4.00	93.24	5.97	6.50
7263	3	2	1	1055	2.16	16	6	72.73	2.49	2.03	.00	66.00	10.00	85.71	5.72	6.17
7263	3	3	1	1065	2.04	16	6	72.73	3.05	3.30	.00	65.00	6.00	90.28	6.10	7.11
7263	4	1	1	1236	2.35	17	5	77.27	2.62	4.39	.00	77.00	5.00	92.77	5.25	6.76
7263	4	2	1	1143	2.27	21	1	95.45	3.70	3.67	.00	67.00	10.00	85.90	5.74	5.36
7263	4	3	1	943	2.10	14	8	63.64	4.00	3.88	.00	60.00	7.00	88.24	6.43	6.82
7263	5	1	1	957	2.07	10	12	45.45	2.99	3.20	.00	65.00	7.00	89.04	5.98	6.94
7263	5	2	1	896	2.12	11	11	50.00	3.40	2.94	.00	63.00	9.00	86.30	5.98	6.83
7263	5	3	1	971	1.85	22	0	100.00	3.47	.00	.00	51.00	6.00	87.93	7.42	9.35
9586	1	1	1	1086	1.93	21	1	95.45	3.73	2.90	.00	58.00	9.00	85.29	6.46	7.15
9586	1	2	1	1130	2.02	22	0	100.00	4.61	.00	.00	59.00	4.00	92.19	6.87	7.19
9586	1	3	1	1088	1.90	20	2	90.91	4.52	1.96	.00	59.00	2.00	95.16	7.11	9.41
9586	2	1	1	987	1.98	21	1	95.45	4.11	2.96	.00	54.00	8.00	85.71	7.00	7.34
9586	2	2	1	1164	1.76	21	1	95.45	3.80	2.56	.00	57.00	.00	98.28	7.64	.00
9586	2	3	1	936	1.79	19	3	86.36	7.04	4.06	.00	51.00	3.00	92.73	7.97	10.01
9586	3	1	1	1217	2.00	22	0	100.00	3.21	.00	.00	67.00	.00	98.53	6.49	.00
9586	3	2	1	1150	1.91	22	0	100.00	4.26	.00	.00	59.00	3.00	93.65	7.09	6.75
9586	3	3	1	1080	1.75	22	0	100.00	4.87	.00	.00	47.00	1.00	95.92	9.11	11.11
9586	4	1	1	1027	2.02	20	2	90.91	6.47	2.36	.00	56.00	2.00	94.92	7.54	6.87
9586	4	2	1	963	1.98	19	2	90.48	7.83	6.07	.00	51.00	4.00	91.07	8.00	7.34
9586	4	3	1	1115	2.04	22	0	100.00	5.34	.00	.00	58.00	4.00	92.06	7.17	5.81
9586	5	1	1	1110	1.91	22	0	100.00	4.63	.00	.00	57.00	3.00	93.44	7.24	7.88
9586	5	2	1	951	1.92	21	1	95.45	6.12	7.20	.00	47.00	7.00	85.45	7.90	9.08
9586	5	3	1	1067	1.83	22	0	100.00	5.73	.00	.00	50.00	4.00	90.91	8.16	7.87
1313	1	1	1	1060	1.96	21	1	95.45	3.66	6.11	.00	52.00	4.00	91.23	7.89	7.23
1313	1	2	1	1058	1.94	21	1	95.45	3.12	4.62	.00	52.00	5.00	89.66	7.86	5.50
1313	1	3	1	1074	2.04	20	2	90.91	3.25	4.43	1.00	57.00	2.00	95.00	7.36	7.85
1313	2	1	1	1112	2.02	19	3	86.36	3.04	3.13	1.00	61.00	2.00	95.31	7.00	5.67
1313	2	2	1	1109	2.14	19	3	86.36	3.79	5.85	.00	62.00	7.00	88.57	6.38	5.88
1313	2	3	1	1207	2.00	22	0	100.00	2.58	.00	.00	61.00	1.00	96.83	7.01	7.58
1313	3	1	1	945	1.77	15	7	68.18	3.02	3.83	2.00	52.00	2.00	94.55	8.11	5.90
1313	3	2	1	1065	1.97	20	2	90.91	2.92	2.23	.00	53.00	3.00	92.98	7.87	6.10
1313	3	3	1	884	1.88	17	5	77.27	4.32	3.48	2.00	44.00	3.00	91.67	9.22	10.35
1313	4	1	1	1191	2.16	21	1	95.45	2.77	2.36	.00	63.00	4.00	92.65	6.47	6.69
1313	4	2	1	1142	2.13	22	0	100.00	3.03	.00	.00	61.00	9.00	85.92	6.14	6.86
1313	4	3	1	1008	1.96	20	2	90.91	2.49	2.69	.00	55.00	6.00	88.71	7.11	7.42
1313	5	1	1	1047	1.97	21	1	95.45	3.38	3.50	.00	55.00	5.00	90.16	7.05	9.30
1313	5	2	1	1095	2.16	18	4	81.82	3.66	1.80	1.00	62.00	3.00	93.94	6.74	5.86
1313	5	3	1	933	1.93	21	1	95.45	3.45	2.01	1.00	47.00	10.00	81.03	7.76	7.33
4033	1	1	1	1099	1.77	18	4	81.82	3.49	3.30	.00	60.00	3.00	93.75	6.97	6.92
4033	1	2	1	1132	1.91	22	0	100.00	3.34	.00	.00	57.00	6.00	89.06	6.97	6.39
4033	1	3	1	1110	1.66	22	0	100.00	3.19	.00	.00	52.00	2.00	94.55	8.00	8.78
4033	2	1	1	923	1.64	16	6	72.73	4.04	4.65	.00	50.00	6.00	87.72	7.73	8.15
4033	2	2	1	1032	1.80	22	0	100.00	2.92	.00	.00	51.00	5.00	89.47	7.69	9.13
4033	2	3	1	1089	1.83	20	2	90.91	3.28	4.16	.00	57.00	3.00	93.44	7.37	8.10
4033	3	1	1	1101	2.04	17	5	77.27	3.61	3.60	.00	65.00	7.00	89.04	5.94	7.54
4033	3	2	1	1112	1.97	22	0	100.00	3.37	.00	.00	59.00	10.00	84.29	6.57	5.64
4033	3	3	1	989	1.86	19	3	86.36	3.31	5.78	.00	52.00	9.00	83.87	6.99	8.20
4033	4	1	1	1000	1.97	15	7	68.18	3.57	4.33	.00	59.00	7.00	88.06	6.69	6.49
4033	4	2	1	970	1.89	18	4	81.82	3.87	6.61	.00	53.00	10.00	82.81	6.97	6.53
4033	4	3	1	1154	1.99	22	0	100.00	3.45	.00	.00	59.00	6.00	89.39	6.69	6.70
4033	5	1	1	1050	2.07	22	0	100.00	3.68	.00	.00	55.00	12.00	80.88	6.48	6.57
4033	5	2	1	1048	1.93	21	1	95.45	3.86	2.03	.00	58.00	10.00	84.06	6.38	7.38
4033	5	3	1	929	1.93	20	2	90.91	3.23	3.24	1.00	51.00	13.00	78.46	6.78	7.48

SYNWORK1 Raw Data

SUBJECT	ALT	TMT	V RSTS	V ADFCRT	V AI RT	V LAPSES	AM PT	AM NT	AM PTD	SUBJECT	ALT	TMT	AM FA	AM PCOR	AM PSD	AM DL
1038	1	1	52.00	41.15	8.39	.00	18.00	72.00	17.00	1038	1	1	.00	100.00	94.44	1.49
1038	1	2	48.00	45.25	9.07	.00	18.00	72.00	18.00	1038	1	2	.00	100.00	100.00	1.36
1038	1	3	51.00	42.16	8.62	.00	18.00	72.00	17.00	1038	1	3	.00	100.00	94.44	1.10
1038	2	1	46.00	47.48	9.68	.00	18.00	72.00	18.00	1038	2	1	.00	100.00	100.00	1.19
1038	2	2	55.00	39.20	8.00	.00	18.00	72.00	18.00	1038	2	2	.00	100.00	100.00	1.19
1038	2	3	51.00	42.24	8.64	.00	18.00	72.00	16.00	1038	2	3	.00	100.00	88.89	1.34
1038	3	1	52.00	41.65	8.49	.00	18.00	72.00	17.00	1038	3	1	.00	100.00	94.44	1.17
1038	3	2	49.00	44.20	9.05	.00	18.00	72.00	17.00	1038	3	2	.00	100.00	94.44	1.88
1038	3	3	55.00	39.35	8.01	.00	18.00	72.00	18.00	1038	3	3	.00	100.00	100.00	1.42
1038	4	1	57.00	38.25	7.79	.00	18.00	72.00	18.00	1038	4	1	.00	100.00	100.00	1.18
1038	4	2	61.00	35.54	7.21	.00	18.00	72.00	18.00	1038	4	2	.00	100.00	100.00	1.24
1038	4	3	55.00	39.20	7.97	.00	18.00	72.00	18.00	1038	4	3	.00	100.00	100.00	1.11
1038	5	1	53.00	40.79	8.31	.00	18.00	72.00	18.00	1038	5	1	.00	100.00	100.00	1.26
1038	5	2	57.00	38.25	7.82	.00	18.00	72.00	18.00	1038	5	2	.00	100.00	100.00	1.28
1038	5	3	64.00	33.81	6.84	.00	18.00	72.00	16.00	1038	5	3	.00	100.00	88.89	1.26
1666	1	1	28.00	78.36	16.10	.00	18.00	72.00	18.00	1666	1	1	.00	100.00	100.00	1.47
1666	1	2	29.00	73.63	15.54	2.00	18.00	72.00	18.00	1666	1	2	.00	100.00	100.00	1.46
1666	1	3	30.00	73.00	15.16	.00	17.00	72.00	16.00	1666	1	3	.00	100.00	94.12	1.81
1666	2	1	30.00	72.21	14.95	1.00	18.00	72.00	18.00	1666	2	1	.00	100.00	100.00	1.46
1666	2	2	32.00	69.00	13.86	.00	18.00	72.00	17.00	1666	2	2	.00	100.00	94.44	1.59
1666	2	3	27.00	80.00	16.49	1.00	18.00	72.00	16.00	1666	2	3	.00	100.00	88.89	1.56
1666	3	1	30.00	73.60	14.83	.00	18.00	72.00	18.00	1666	3	1	.00	100.00	100.00	1.50
1666	3	2	26.00	84.46	17.13	.00	18.00	72.00	18.00	1666	3	2	.00	100.00	100.00	1.50
1666	3	3	26.00	82.96	16.98	1.00	18.00	72.00	18.00	1666	3	3	.00	100.00	100.00	1.68
1666	4	1	30.00	70.87	14.35	.00	18.00	72.00	17.00	1666	4	1	.00	100.00	94.44	1.32
1666	4	2	36.00	59.83	12.47	1.00	18.00	72.00	17.00	1666	4	2	1.00	94.44	94.44	1.55
1666	4	3	33.00	64.42	13.02	.00	18.00	72.00	16.00	1666	4	3	1.00	94.12	88.89	1.58
1666	5	1	28.00	78.86	15.91	.00	18.00	72.00	17.00	1666	5	1	.00	100.00	94.44	1.44
1666	5	2	27.00	81.11	16.46	.00	18.00	72.00	18.00	1666	5	2	1.00	94.74	100.00	1.58
1666	5	3	30.00	73.33	14.95	.00	17.00	72.00	17.00	1666	5	3	1.00	94.44	100.00	1.31
1843	1	1	55.00	40.00	8.04	.00	18.00	72.00	17.00	1843	1	1	.00	100.00	94.44	1.58
1843	1	2	54.00	40.67	8.33	.00	18.00	72.00	18.00	1843	1	2	.00	100.00	100.00	1.62
1843	1	3	52.00	42.31	8.45	.00	18.00	72.00	16.00	1843	1	3	.00	100.00	88.89	1.46
1843	2	1	58.00	38.00	7.58	.00	18.00	72.00	18.00	1843	2	1	.00	100.00	100.00	1.48
1843	2	2	59.00	37.29	7.58	.00	18.00	72.00	17.00	1843	2	2	.00	100.00	94.44	1.57
1843	2	3	50.00	44.00	9.00	.00	18.00	72.00	16.00	1843	2	3	.00	100.00	88.89	1.42
1843	3	1	54.00	40.70	8.37	.00	18.00	72.00	18.00	1843	3	1	.00	100.00	100.00	1.58
1843	3	2	52.00	42.46	8.68	.00	18.00	72.00	17.00	1843	3	2	.00	100.00	94.44	1.97
1843	3	3	51.00	42.63	8.61	.00	18.00	72.00	16.00	1843	3	3	.00	100.00	88.89	1.50
1843	4	1	58.00	37.83	7.71	.00	18.00	72.00	18.00	1843	4	1	.00	100.00	100.00	1.46
1843	4	2	62.00	34.94	7.05	.00	18.00	71.00	18.00	1843	4	2	.00	100.00	100.00	1.48
1843	4	3	58.00	37.86	7.69	.00	18.00	72.00	17.00	1843	4	3	.00	100.00	94.44	1.43
1843	5	1	56.00	39.18	8.01	.00	18.00	72.00	18.00	1843	5	1	.00	100.00	100.00	1.35
1843	5	2	55.00	39.85	8.14	.00	18.00	72.00	18.00	1843	5	2	.00	100.00	100.00	1.40
1843	5	3	58.00	37.97	7.71	.00	18.00	72.00	16.00	1843	5	3	.00	100.00	88.89	1.32
3266	1	1	38.00	57.16	11.53	.00	18.00	72.00	17.00	3266	1	1	.00	100.00	94.44	1.50
3266	1	2	41.00	51.90	10.58	.00	18.00	72.00	18.00	3266	1	2	1.00	94.74	100.00	1.27
3266	1	3	44.00	48.82	9.88	.00	18.00	72.00	16.00	3266	1	3	.00	100.00	88.89	1.44
3266	2	1	40.00	53.95	10.89	.00	18.00	72.00	17.00	3266	2	1	.00	100.00	94.44	1.15
3266	2	2	38.00	56.47	11.41	.00	18.00	72.00	17.00	3266	2	2	.00	100.00	94.44	1.33
3266	2	3	35.00	61.83	12.52	.00	18.00	72.00	18.00	3266	2	3	.00	100.00	100.00	1.27
3266	3	1	42.00	51.00	10.17	.00	18.00	72.00	16.00	3266	3	1	.00	100.00	88.89	1.04
3266	3	2	42.00	50.52	10.22	.00	18.00	72.00	18.00	3266	3	2	.00	100.00	100.00	1.18
3266	3	3	46.00	47.57	9.69	.00	18.00	72.00	17.00	3266	3	3	.00	100.00	94.44	1.11
3266	4	1	41.00	53.37	10.71	.00	18.00	72.00	18.00	3266	4	1	.00	100.00	100.00	1.28
3266	4	2	38.00	56.32	11.42	.00	18.00	72.00	18.00	3266	4	2	.00	100.00	100.00	1.11
3266	4	3	40.00	53.90	10.80	.00	18.00	72.00	17.00	3266	4	3	.00	100.00	94.44	1.11
3266	5	1	38.00	56.58	11.27	.00	18.00	72.00	17.00	3266	5	1	.00	100.00	94.44	1.21
3266	5	2	36.00	60.17	12.13	.00	18.00	72.00	18.00	3266	5	2	.00	100.00	100.00	1.25
3266	5	3	37.00	58.70	11.80	.00	18.00	72.00	18.00	3266	5	3	.00	100.00	100.00	1.67
3562	1	1	40.00	53.80	10.79	.00	18.00	72.00	16.00	3562	1	1	.00	100.00	88.89	1.58
3562	1	2	45.00	47.51	9.56	.00	18.00	72.00	18.00	3562	1	2	.00	100.00	100.00	1.42
3562	1	3	50.00	43.20	8.71	.00	17.00	72.00	15.00	3562	1	3	1.00	93.75	88.24	1.75
3562	2	1	32.00	66.63	13.40	.00	18.00	71.00	17.00	3562	2	1	.00	100.00	94.44	1.52
3562	2	2	37.00	58.59	11.83	.00	18.00	72.00	17.00	3562	2	2	1.00	94.44	94.44	2.17
3562	2	3	41.00	52.39	10.38	.00	18.00	72.00	18.00	3562	2	3	.00	100.00	100.00	1.20
3562	3	1	45.00	48.00	9.59	.00	18.00	71.00	18.00	3562	3	1	.00	100.00	100.00	1.41
3562	3	2	47.00	44.85	8.96	.00	18.00	72.00	17.00	3562	3	2	.00	100.00	94.44	1.37
3562	3	3	55.00	39.45	7.93	.00	18.00	72.00	17.00	3562	3	3	.00	100.00	94.44	1.57
3562	4	1	45.00	47.91	9.52	.00	18.00	72.00	17.00	3562	4	1	.00	100.00	94.44	1.62
3562	4	2	50.00	43.00	8.52	.00	18.00	72.00	17.00	3562	4	2	.00	100.00	94.44	1.57
3562	4	3	60.00	35.73	7.23	.00	18.00	72.00	16.00	3562	4	3	.00	100.00	88.89	1.52
3562	5	1	43.00	50.37	9.96	.00	18.00	72.00	17.00	3562	5	1	.00	100.00	94.44	1.66
3562	5	2	50.00	43.08	8.63	.00	18.00	72.00	18.00	3562	5	2	.00	100.00	100.00	2.01
3562	5	3	54.00	39.44	7.96	.00	18.00	72.00	11.00	3562	5	3	.00	100.00	61.11	1.46
7627	1	1	28.00	77.50	15.56	.00	18.00	72.00	17.00	7627	1	1	.00	100.00	94.44	1.96
7627	1	2	27.00	80.37	16.09	.00	18.00	72.00	17.00	7627	1	2	.00	100.00	94.44	1.56
7627	1	3	27.00	80.15	16.12	.00	18.00	72.00	17.00	7627	1	3	.00	100.00	94.44	1.36
7627	2	1	27.00	79.11	16.08	.00	18.00	72.00	12.00	7627	2	1	.00	100.00	66.67	1.52
7627	2	2	26.00	82.62	16.59	.00	18.00	72.00	18.00	7627	2	2	.00	100.00	100.00	1.68
7627	2	3	25.00	82.58	16.69	2.00	18.00	72.00	14.00	7627	2	3	.00	100.00	77.78	1.40
7627	3	1	27.00	77.15	15.54	1.00	18.00	72.00	16.00	7627	3	1	1.00	94.12	88.89	1.90
7627	3	2	28.00	76.79	15.29	.00	18.00	72.00	16.00	7627	3	2	.00	100.00	88.89	1.76
7627	3	3	27.00	80.30	16.08	.00	18.00	72.00	16.00	7627	3	3	2.00	88.89	88.89	1.48
7627	4	1	27.00	78.74	15.92	.00	18.00	72.00	15.00	7627	4	1	.00	100.00	83.33	1.70
7627	4	2	27.00	78.52	15.95	.00	18.00	72.00	14.00	7627	4	2	.00	100.00	77.78	1.67
7627	4	3	27.00	80.30	16.06	.00	18.00	72.00	16.00	7627	4	3	.00	100.00	88.89	1.44
7627	5	1	28.00	76.43	15.36	.00	18.00	72.00	18.00	7627	5	1	.00	100.00	100.00	1.53
7627	5	2	29.00	74.48	14.88	.00	18.00	72.00	16.00	7627	5	2	1.00	94.12	88.89	1.48
7627	5	3	28.00	77.36	15.57	.00	18.00	71.00	17.00	7627	5	3	.00	100.00	94.44	1.47
8939	1	1	39.00	55.90	11.49	.00	18.00	71.00	18.00	8939	1	1	.00	100.00	100.00	1.31
8939	1	2	37.00	58.54	12.14	.00	18.00	72.00	17.00	8939	1	2	1.00	94.44	94.44	1.98
8939	1	3	39.00	55.64	11.45	.00	18.00	72.00	17.00	8939	1	3	.00	100.00	94.44	2.12
8939	2	1	79.00	27.77	5.60	.00	18.00	72.00	17.00	8939	2	1	.00	100.00	94.44	2.00
8939	2	2	77.00	28.21	5.66	.00	18.00	71.00	18.00	8939	2	2	.00	100.00	100.00	2.31
8939	2	3	79.00	27.59	5.62	.00	18.00	72.00	16.00	8939	2	3	.00	100.00	88.89	1.90
8939	3	1	42.00	51.57	10.61	.00	18.00	72.00	18.00	8939	3	1	1.00	94.74	100.00	2.51
8939	3	2	42.00	51.57	10.60	.00	18.00	72.00	18.00	8939	3	2	2.00	90.00	100.00	2.10
8939	3	3	40.00	54.40	11.22	.00	18.00	72.00	15.00	8939	3	3	.00	100.00	83.33	2.05
8939	4	1	63.00	33.34	6.74	.00	17.00	71.00	16.00	8939	4	1	.00	100.00	94.12	2.24
8939	4	2	79.00	27.67	5.61	.00	18.00	72.00	17.00	8939	4	2	.00	100.00	94.44	2.04
8939	4	3	73.00	29.70	5.92	.00	18.00	72.00	18.00	8939	4	3	2.00	90.00	100.00	2.21
8939	5	1	41.00	52.34	10.79	.00	18.00	72.00	18.00	8939	5	1	1.00	94.74	100.00	2.02
8939	5	2	42.00	51.62	10.59	.00	18.00	72.00	18.00	8939	5	2	.00	100.00	100.00	2.00
8939	5	3	39.00	55.38	11.42	.00	18.00	72.00	18.00	8939	5	3	.00	100.00	100.00	2.22
9446	1	1	22	97.58	19.88	3	18	72	17	9446	1	1	0	100	94.44	1.21
9446	1	2	22	97.3	19.83	2	18	72	18	9446	1	2	0	100	100	1.12
9446	1	3	22	96.7	19.68	2	18	72	17	9446	1	3	0	100	94.44	1.13

SYNWORK1 Raw Data

9446	2	1	21	98.7	20.21	2	18	72	17	9446	2	1	0	100	94.44	1.21
9446	2	2	22	96.32	19.87	3	18	72	18	9446	2	2	0	100	100	1.33
9446	2	3	22	97.91	19.79	0	18	72	17	9446	2	3	0	100	94.44	1.13
9446	3	1	21	99.2	20.17	2	18	72	17	9446	3	1	0	100	94.44	1.15
9446	3	2	21	98.84	20.2	3	18	72	16	9446	3	2	0	100	88.89	1.29
9446	3	3	21	98.95	20.18	3	18	72	17	9446	3	3	0	100	94.44	1.22
9446	4	1	21	99.33	20.11	1	18	72	18	9446	4	1	0	100	100	1.31
9446	4	2	22	97.8	19.92	2	18	72	18	9446	4	2	0	100	100	1.25
9446	4	3	21	98.22	20.26	4	18	72	17	9446	4	3	0	100	94.44	1.13
9446	5	1	22	97.33	19.82	1	18	72	18	9446	5	1	0	100	100	1.2
9446	5	2	22	96.55	19.44	0	18	72	17	9446	5	2	0	100	94.44	1.26
9446	5	3	22	96.48	19.62	1	18	72	18	9446	5	3	0	100	100	1.18
1913	1	1	59.00	36.98	7.44	.00	18.00	72.00	16.00	1913	1	1	.00	100.00	88.89	1.22
1913	1	2	47.00	45.74	9.17	.00	18.00	72.00	18.00	1913	1	2	.00	100.00	100.00	1.49
1913	1	3	53.00	40.26	8.04	.00	18.00	72.00	17.00	1913	1	3	1.00	94.44	94.44	1.36
1913	2	1	60.00	35.97	7.31	.00	18.00	72.00	16.00	1913	2	1	.00	100.00	88.89	1.13
1913	2	2	54.00	40.19	8.09	.00	18.00	72.00	17.00	1913	2	2	.00	100.00	94.44	1.36
1913	2	3	58.00	37.52	7.56	.00	18.00	72.00	18.00	1913	2	3	.00	100.00	100.00	1.10
1913	3	1	74.00	29.14	5.89	.00	18.00	72.00	18.00	1913	3	1	.00	100.00	100.00	1.43
1913	3	2	82.00	26.44	5.37	.00	18.00	72.00	18.00	1913	3	2	.00	100.00	100.00	1.25
1913	3	3	66.00	33.09	6.68	.00	18.00	72.00	17.00	1913	3	3	.00	100.00	94.44	1.10
1913	4	1	57.00	38.04	7.75	.00	18.00	72.00	17.00	1913	4	1	.00	100.00	94.44	1.36
1913	4	2	56.00	38.61	7.77	.00	18.00	72.00	17.00	1913	4	2	.00	100.00	94.44	1.50
1913	4	3	61.00	35.11	7.15	.00	18.00	72.00	18.00	1913	4	3	.00	100.00	100.00	1.09
1913	5	1	44.00	47.82	9.68	1.00	18.00	72.00	17.00	1913	5	1	.00	100.00	94.44	1.54
1913	5	2	57.00	37.65	7.58	.00	18.00	72.00	18.00	1913	5	2	.00	100.00	100.00	1.60
1913	5	3	51.00	41.80	8.36	.00	18.00	72.00	17.00	1913	5	3	.00	100.00	94.44	1.31
4749	1	1	38.00	56.63	11.40	.00	18.00	72.00	17.00	4749	1	1	.00	100.00	94.44	1.58
4749	1	2	42.00	51.14	10.15	.00	18.00	72.00	18.00	4749	1	2	.00	100.00	100.00	1.33
4749	1	3	44.00	49.32	9.75	.00	18.00	72.00	17.00	4749	1	3	.00	100.00	94.44	1.20
4749	2	1	42.00	51.00	10.27	.00	18.00	72.00	18.00	4749	2	1	.00	100.00	100.00	1.67
4749	2	2	45.00	48.04	9.58	.00	18.00	72.00	18.00	4749	2	2	.00	100.00	100.00	1.31
4749	2	3	45.00	48.53	9.83	.00	18.00	72.00	17.00	4749	2	3	.00	100.00	94.44	1.64
4749	3	1	39.00	55.79	11.34	.00	18.00	72.00	17.00	4749	3	1	.00	100.00	94.44	1.13
4749	3	2	37.00	58.05	11.64	.00	18.00	72.00	17.00	4749	3	2	.00	100.00	94.44	1.32
4749	3	3	39.00	52.95	10.70	1.00	18.00	72.00	18.00	4749	3	3	.00	100.00	100.00	1.26
4749	4	1	38.00	56.84	11.37	.00	18.00	72.00	18.00	4749	4	1	.00	100.00	100.00	1.33
4749	4	2	42.00	50.62	10.30	.00	18.00	72.00	17.00	4749	4	2	.00	100.00	94.44	1.25
4749	4	3	44.00	49.23	9.79	.00	18.00	72.00	16.00	4749	4	3	.00	100.00	88.89	1.33
4749	5	1	40.00	54.25	10.93	.00	18.00	72.00	18.00	4749	5	1	.00	100.00	100.00	1.33
4749	5	2	41.00	53.27	10.63	.00	18.00	72.00	18.00	4749	5	2	1.00	94.74	100.00	1.48
4749	5	3	44.00	49.36	9.93	.00	18.00	72.00	18.00	4749	5	3	1.00	94.74	100.00	1.25
7263	1	1	30.00	71.87	14.61	.00	18.00	72.00	18.00	7263	1	1	.00	100.00	100.00	1.80
7263	1	2	33.00	64.67	12.95	.00	18.00	72.00	18.00	7263	1	2	.00	100.00	100.00	1.37
7263	1	3	31.00	67.35	13.50	1.00	18.00	72.00	18.00	7263	1	3	.00	100.00	100.00	1.41
7263	2	1	33.00	65.88	13.25	.00	18.00	72.00	17.00	7263	2	1	.00	100.00	94.44	1.42
7263	2	2	38.00	57.11	11.52	.00	18.00	72.00	18.00	7263	2	2	.00	100.00	100.00	1.37
7263	2	3	32.00	64.87	13.69	2.00	18.00	72.00	18.00	7263	2	3	.00	100.00	100.00	1.44
7263	3	1	39.00	55.18	11.09	.00	18.00	72.00	17.00	7263	3	1	.00	100.00	94.44	1.53
7263	3	2	34.00	64.12	13.13	.00	18.00	72.00	18.00	7263	3	2	.00	100.00	100.00	1.70
7263	3	3	36.00	59.72	11.95	.00	18.00	72.00	17.00	7263	3	3	1.00	94.44	94.44	1.56
7263	4	1	28.00	77.57	15.82	.00	18.00	72.00	18.00	7263	4	1	.00	100.00	100.00	1.57
7263	4	2	28.00	75.00	14.99	1.00	18.00	72.00	18.00	7263	4	2	.00	100.00	100.00	1.27
7263	4	3	31.00	66.87	13.61	1.00	18.00	72.00	16.00	7263	4	3	.00	100.00	88.89	1.66
7263	5	1	32.00	67.88	13.82	.00	18.00	72.00	18.00	7263	5	1	.00	100.00	100.00	1.61
7263	5	2	34.00	62.61	12.83	1.00	18.00	72.00	17.00	7263	5	2	.00	100.00	94.44	1.44
7263	5	3	30.00	69.10	14.31	1.00	18.00	72.00	13.00	7263	5	3	.00	100.00	72.22	1.77
9586	1	1	28.00	78.00	15.55	.00	18.00	71.00	18.00	9586	1	1	.00	100.00	100.00	1.28
9586	1	2	27.00	76.85	15.83	1.00	18.00	72.00	18.00	9586	1	2	.00	100.00	100.00	1.77
9586	1	3	31.00	68.14	14.14	2.00	18.00	72.00	16.00	9586	1	3	.00	100.00	88.89	1.78
9586	2	1	28.00	73.00	15.30	2.00	18.00	72.00	17.00	9586	2	1	.00	100.00	94.44	1.33
9586	2	2	27.00	78.81	15.82	.00	18.00	72.00	18.00	9586	2	2	.00	100.00	100.00	1.19
9586	2	3	26.00	78.72	16.29	2.00	18.00	72.00	17.00	9586	2	3	.00	100.00	94.44	1.37
9586	3	1	31.00	67.07	14.58	3.00	18.00	72.00	18.00	9586	3	1	.00	100.00	100.00	1.35
9586	3	2	33.00	65.75	13.77	1.00	18.00	72.00	17.00	9586	3	2	.00	100.00	94.44	1.35
9586	3	3	34.00	64.53	13.06	.00	18.00	72.00	18.00	9586	3	3	.00	100.00	100.00	1.38
9586	4	1	27.00	77.84	16.12	2.00	18.00	72.00	15.00	9586	4	1	.00	100.00	83.33	1.47
9586	4	2	26.00	81.00	16.77	2.00	18.00	72.00	17.00	9586	4	2	.00	100.00	94.44	1.29
9586	4	3	30.00	70.14	14.87	2.00	18.00	72.00	18.00	9586	4	3	.00	100.00	100.00	1.48
9586	5	1	31.00	69.73	14.26	1.00	17.00	72.00	16.00	9586	5	1	1.00	94.12	94.12	1.73
9586	5	2	31.00	68.62	14.56	2.00	18.00	72.00	18.00	9586	5	2	.00	100.00	100.00	1.54
9586	5	3	37.00	59.84	12.22	.00	18.00	72.00	17.00	9586	5	3	.00	100.00	94.44	1.32
1313	1	1	25.00	84.40	16.96	.00	17.00	72.00	17.00	1313	1	1	.00	100.00	100.00	1.58
1313	1	2	24.00	91.00	18.31	.00	18.00	72.00	18.00	1313	1	2	1.00	94.74	100.00	1.51
1313	1	3	24.00	88.70	18.10	1.00	18.00	72.00	17.00	1313	1	3	.00	100.00	94.44	1.50
1313	2	1	23.00	91.64	18.59	1.00	18.00	72.00	18.00	1313	2	1	.00	100.00	100.00	1.71
1313	2	2	24.00	90.42	18.18	.00	18.00	72.00	18.00	1313	2	2	.00	100.00	100.00	2.00
1313	2	3	24.00	90.33	18.25	.00	18.00	72.00	17.00	1313	2	3	.00	100.00	94.44	1.44
1313	3	1	24.00	89.33	18.08	.00	18.00	72.00	17.00	1313	3	1	.00	100.00	94.44	1.64
1313	3	2	24.00	89.17	17.97	.00	18.00	72.00	18.00	1313	3	2	1.00	94.74	100.00	1.59
1313	3	3	25.00	84.25	17.16	1.00	18.00	72.00	18.00	1313	3	3	.00	100.00	100.00	1.76
1313	4	1	23.00	95.30	19.45	.00	18.00	72.00	18.00	1313	4	1	.00	100.00	100.00	1.70
1313	4	2	24.00	92.00	18.63	.00	18.00	72.00	18.00	1313	4	2	.00	100.00	100.00	1.50
1313	4	3	23.00	93.71	19.30	2.00	18.00	72.00	16.00	1313	4	3	.00	100.00	88.89	1.61
1313	5	1	22.00	94.55	19.14	1.00	18.00	72.00	18.00	1313	5	1	.00	100.00	100.00	1.95
1313	5	2	23.00	92.73	18.82	1.00	18.00	72.00	18.00	1313	5	2	.00	100.00	100.00	1.65
1313	5	3	23.00	92.18	18.64	1.00	18.00	72.00	18.00	1313	5	3	.00	100.00	100.00	1.96
4033	1	1	30.00	73.47	14.73	.00	18.00	72.00	17.00	4033	1	1	.00	100.00	94.44	1.52
4033	1	2	28.00	78.64	15.94	.00	18.00	72.00	18.00	4033	1	2	.00	100.00	100.00	1.29
4033	1	3	29.00	76.28	15.40	.00	18.00	72.00	17.00	4033	1	3	.00	100.00	94.44	1.38
4033	2	1	27.00	78.67	15.83	.00	18.00	72.00	17.00	4033	2	1	.00	100.00	94.44	1.40
4033	2	2	28.00	74.00	14.91	1.00	18.00	72.00	17.00	4033	2	2	.00	100.00	94.44	1.38
4033	2	3	26.00	79.92	16.22	1.00	18.00	72.00	18.00	4033	2	3	.00	100.00	100.00	1.56
4033	3	1	30.00	73.40	14.87	.00	18.00	72.00	18.00	4033	3	1	.00	100.00	100.00	1.59
4033	3	2	28.00	78.36	15.78	.00	18.00	72.00	18.00	4033	3	2	.00	100.00	100.00	1.48
4033	3	3	27.00	81.04	16.53	.00	18.00	72.00	18.00	4033	3	3	.00	100.00	100.00	1.77
4033	4	1	29.00	76.14	15.35	.00	18.00	72.00	18.00	4033	4	1	.00	100.00	100.00	1.46
4033	4	2	28.00	78.21	15.89	.00	18.00	72.00	18.00	4033	4	2	.00	100.00	100.00	1.63
4033	4	3	31.00	71.23	14.40	.00	18.00	72.00	18.00	4033	4	3	.00	100.00	100.00	1.70
4033	5	1	28.00	78.50	16.03	.00	18.00	72.00	18.00	4033	5	1	.00	100.00	100.00	2.00
4033	5	2	27.00	80.46	16.58	1.00	18.00	72.00	17.00	4033	5	2	.00	100.00	94.44	1.90
4033	5	3	26.00	84.15	17.05	.00	18.00	72.00	16.00	4033	5	3	.00	100.00	88.89	1.68