PHYSIOLOGICAL AND PERCEIVED EFFECTS OF HEAD COOLING
DURING SIMULATED FIREFIGHTING ACTIVITY

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ABSTRACT

Accessory cooling devices have been developed to protect firefighters (FF) from suffering an exertional heat illness by attenuating the rise in core body temperature. Head cooling (HC) via a cold gel pack placed inside the helmet is one cooling mechanism marketed to FF, but the research regarding its efficacy is limited.

PURPOSE: To investigate the physiological and perceived effects of HC during simulated firefighting activity (FFA).

METHODS: Participants (males; 40 ± 8 y; 168 ± 7 cm; 91.8 ± 14.2 kg) were randomly assigned to either the HC group ($n=9$), who completed FFA while wearing a cold gel pack inside their helmet, or the control (CON) group ($n=10$), who received no accessory cooling during FFA. FF completed four FFA stations in full turnout gear and self-contained breathing apparatus (SCBA) (23.3 ± 1.4 kg). FFA stations lasted 15 min and included an obstacle course, a high-rise drill, a two-story search and rescue drill, and car extrication. Stations were completed in random order. After each station, FF replaced their air cylinder and HC replaced their gel pack; FF then completed a different station. After every two stations, the FF rested for 15 min in the shade by removing their turnout gear and SCBA and drinking water ad libitum. Gastrointestinal temperature (GI), heart rate (HR), Stroop Test interference score (ST), rating of perceived exertion (RPE), perceived thermal strain (PTS), and hydration status were measured. Repeated-measures ANOVAs were used to compare groups across time.

RESULTS: No significant demographic differences were found between groups ($p>0.05$). GI ($39.18\pm0.49^{\circ}\text{C}$) and HR ($163\pm22\text{bpm}$) increased during FFA. No significant interactions were found for GI, HR, ST, PTS, or RPE ($p>0.05$). There were no differences in sweat loss ($2.5\pm0.8\text{ L}$), hypohydration ($0.9\pm0.8\%$), or post FFA urine specific gravity (1.020 ± 0.008) between groups ($p>0.05$). Weak relationships were noted between perceived thermal sensation and gastrointestinal temperature ($r=.248$).

CONCLUSION: HC did not attenuate the rise in GI or reduce HR during FFA. The discrepancy between perception and actual body temperature may be dangerous for FF, as it may allow them to work beyond their central drive and the critical GI threshold.

PREFACE

Like many young graduate students, I wanted to immediately make a difference. I wanted my research to find the ultimate prevention for all exertional heat illnesses. And like many good and experienced advisors, my committee steered me toward a much more manageable piece to the puzzle that would still make a significant impact. As the ideas came together and took shape, we created a project that would not only contribute to the body of literature, but also to some members of our community. This allowed me to weave my own desire to work with firefighters, the atypical yet professional athlete many of my family members have become, into my plan to help prevent exertional heat illnesses.

Although the numbers and statistics from the study taught me about head cooling, the firefighters who volunteered their time, sweat, talent, and expertise taught me about people. Their interest and excitement throughout the project were driving factors in the completion of the study. Their desire to learn about thermal physiology and their own reactions to exercise in the heat led to sharing their personal data collected during the study with them to increase their self-awareness and improve how they care for themselves. The experience of working with these firefighters is one that cannot be replaced and was truly the personal significance I found during this study.

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CHAPTER 1

INTRODUCTION

Firefighters are forced to handle a variety of physiological stressors while on the job. He or she must repeatedly enter burning buildings with temperatures as high as 278°C¹ and sustain long periods of physical exertion while working to extinguish fires and rescue victims. Further, they must complete all of these tasks while wearing heavy protective clothing and a self-contained breathing apparatus.² With the combination of their protective clothing, the hot environment, and their physical exertion, firefighters' core body temperatures (CBT) increase³ and they become unable to dissipate the heat. As they work hard to extinguish a fire, heart rate (HR) also increases³⁻⁶ resulting in an increased physiological strain.² With this increased physiological stress, firefighters also perceive that they feel hotter and feel as though they are working harder.⁶

As the body stores heat CBT continues to rise, increasing the risk of developing an exertional heat illness (EHI).⁷⁻¹¹ Many types of EHIs exist, including cramps, syncope, exhaustion, and stroke. The temperature, humidity, intensity of work, length of exposure to the environment, protective clothing, dehydration, illness, and lack of sleep may contribute to the development of a heat illness.⁸⁻¹¹ Any EHI can render a firefighter unable to continue working to extinguish a fire, thus reducing the work force; it may even lead to a firefighter's death.

Heat illness in firefighters is not uncommon.¹²⁻¹⁴ The National Fire Protection Association's Research and Analysis Division reported that between 2003 and 2006, 2330 illnesses due to exhaustion or fatigue, including heat exhaustion were reported.¹² Over 1300 firefighters reported dizziness, fainting, weakness, dehydration, or nausea as the primary symptom.¹² All of these symptoms may be related to an EHI; however, specific data on the occurrence of EHIs is lacking in firefighters. Among the firefighters who suffer from an EHI, not everyone survives. In both 2008 and 2009, one firefighter died as a result of heat stroke and heat exhaustion, respectively.^{13, 14} Additionally, 52 firefighters in 2009 and 41 in 2008 died due to stress and overexertion.¹³

Several safety procedures exist to help protect firefighters during training and on the job.¹⁵⁻¹⁹ Accessory cooling devices and methods, such as ice vests, fan and water mists, and forearm and hand cold-water submersion may also assist in preventing EHIs.^{6, 20-23} These devices function to attenuate the rise in CBT, thus reducing the firefighter's risk of developing an EHI. Head cooling is one method that has been studied in various settings and activity levels²⁴⁻²⁶, but not among firefighters. One product, the GelCool gel pack, is cooled in a freezer and then is worn inside a firefighter's helmet during activity to help keep the firefighter cool. The manufacturer claims that the device cools cranial blood thus reducing metabolic activity. They claim that this will slow vital organ (heart and lungs) activity.²⁷ They also claim that with cooler blood circulating, the need to dissipate heat will decrease, thus reducing perspiration.²⁷ Although this product makes many claims that seem to benefit the firefighters, the manufacturer has provided no evidence to support their claims. The purpose of this study is to determine if a GelCool

gel pack worn inside of firefighting helmets during activity is beneficial to firefighters by attenuating the rise in CBT and thus reducing the risk of developing an EHI.

Research Question

What effect does superior head cooling have on physiological, perceptual, and cognitive responses during simulated firefighting activity?

Experimental Hypotheses

- Wearing the GelCool gel pack will not attenuate the rise of gastrointestinal (GI) temperature, HR, or Physiological Strain Index (PSI) score.
- Wearing the GelCool gel pack will reduce firefighters' rate of perceived exertion (RPE) and perceived thermal strain (PTS).
- Wearing the GelCool gel pack will not reduce body mass loss, sweat rate, or sweat loss or improve urine specific gravity measurements.
- Wearing the GelCool gel pack will not improve cognitive function on the Stroop Word Test.

CHAPTER 2

REVIEW OF LITERATURE

Firefighters are praised for their bravery and courage as they repeatedly enter burning buildings to help those in need. They are constantly under stress from the heat of the flames, their protective clothing, and their physical exertion that causes their CBT to rise while they work. This review of literature describes how firefighters' bodies store and dissipate heat, the physiological responses to the storage of that heat in the general population, as well as specific responses in firefighters. Since the incidence of EHI in firefighters is high, exertional heat stroke and exertional heat exhaustion are discussed, as well as predisposing factors that contribute to the development of an EHI. Many methods of prevention, including safety protocols and various cooling methods, are also included in this review of literature.

Search Strategy

Searches on the topic were completed in the following databases: Cochrane, PubMed, PubMed Central, CINAHL, PreCINAHL, and Medline, and by hand searching. The following key words were used individually and in combination to search the literature: exertional heat illness, exertional heat stroke, exertional heat exhaustion, firefighter, physiology, perceived, perceptual, temperature, heart rate, heat,

acclimatization, prevalence, incidence, prevention, predisposing, safety, and cooling.

Inclusion criteria included firefighters, exercise, intermittent exercise, protective clothing, heat stress, and heat strain. Exclusion criteria included abnormal populations, malignant hyperthermia, and animals.

Environmental Exercise Physiology

Heat Acquisition

Metabolic heat produced during exercise from the contraction and active use of muscles puts thermal stress on the body. Greater exercise intensities produce more metabolic heat within the body, thus increasing the amount of heat stored by the body as well as increasing CBT.^{7, 8, 28} Core body temperature will rise in proportion to the increase in exercise intensity and can be compensated for in an appropriate environment.²⁸

However, when the ambient temperature rises above 25°C, core temperature begins to increase as ambient temperature increases.²⁸ Therefore, the environment in which one exercises can put additional stress on the body. The body acquires heat from many external factors such as ambient temperature, humidity, solar radiation, thermal radiation from the ground, and protective clothing.⁷ These factors are commonly present in the environment in which a firefighter works. During firefighting, Rossi et al. found temperatures to range from 50-130°C on the ground to 100-190°C at 1 meter above the ground with a maximum of 278°C experienced during a heat flux in a simulated domestic fire.¹ Sensors placed on the bottom and top of the firefighters jackets found temperatures in the range of 40-70°C and 50-120°C, respectively.¹ In this study, while they could not directly measure humidity, they observed that black smoke turned to a white mist while

extinguishing the fire, indicating that partial pressure could be near saturation and therefore a high humidity was present.¹

Protective clothing worn by firefighters to protect them from thermal injuries insulates the body and aids the increase in CBT beyond what is caused by the environmental temperature and physical work.²⁹ The protective clothing worn by firefighters also reduces the surface area of the body exposed to the air, which reduces the body's means of dissipating heat.³⁰ Kalyani et al. evaluated the physiological strain firefighters experienced while performing physical activity in their firefighting protective clothing versus typical work clothing while completing the Bruce exercise protocol in a thermoneutral environment. Physiological strain experienced by the participants in each set of clothing was evaluated with the Physiological Strain Index. The PSI in firefighting protective clothing was significantly greater compared to typical work clothing, indicating a greater level of strain on the body due to heat, especially with respect to increases in CBT and HR.³¹

Heat Dissipation

While the body acquires this heat during exercise in a hot environment, it must find a way to dissipate the heat in order to maintain CBT within a safe range. Heat dissipation can occur via conduction, convection, radiation, and evaporation. Heat transfer by conduction is the movement of heat between two objects in direct contact with one another and is insignificant at most times.⁷ At lower ambient temperatures (5-10°C), convection and radiation are the principal means of heat loss.^{28, 30} However, as ambient temperature increases, heat dissipation via convection and radiation is reduced.^{7, 28, 30} Convection is the transfer of heat between one object and a moving medium, such as air

or water, surrounding it, while radiation is the movement of heat by electromagnetic waves due to the temperature of the object. As ambient temperature increases, evaporation, the loss of heat via the process of changing the state of a liquid to a gas, becomes the principal method for removing heat from the body.^{7, 28, 30} However, evaporation can only be accomplished with the body's sweating mechanism, hydration status, and the environment's optimal humidity working together. If one becomes hypohydrated or otherwise compromises the body's sweating mechanism, heat dissipation also becomes compromised.⁷ Additionally, high humidity (greater than 50-70%)⁸ in the environment reduces the effect of evaporation on cooling the body.^{7, 30} If the body becomes overwhelmed and unable to dissipate as much heat as it acquires, hyperthermia results.^{7, 8, 10, 30} This increased CBT has many physiological and performance consequences.^{7, 8} Hyperthermia reduces muscular endurance and shifts the body's metabolism from aerobic to anaerobic.^{8, 28} This change in metabolism causes the body to use its limited store of carbohydrates much faster and provides less oxygen to working tissues.⁸ Hyperthermia also causes a change in blood flow throughout the body, increasing cardiovascular strain.⁸ The effects of these changes have been found to manifest as a perception of fatigue.⁸

Physiology of Exercise in the Heat

In an attempt to dissipate as much heat as the body acquires, physiological alterations will occur. Initially, blood begins to be shunted away from inactive tissues and the gut toward the skin and active muscles for heat dissipation and to continue exercise, respectively. This results in splanchnic vasoconstriction and peripheral vasodilation of the skin and muscles. Although blood flow has been shunted to help cool the body, the

active muscles and cutaneous blood vessels are still competing for blood flow.²⁸ By increasing cutaneous blood flow, heat is carried away from the body's core and heat dissipation via convection is enhanced.^{8, 10} The heat brought to the skin's surface can transfer to the environment via the temperature gradient created between the blood and the environment. The dissipation of heat away from the body can only occur if the environmental temperature is lower than the temperature of the blood. As the environmental temperature increases to greater than 34-37°C, heat dissipation due to peripheral vasodilation is reduced.⁸

As the body shunts blood to the periphery in attempt to dissipate heat, central blood volume is reduced.^{7, 28} It is also reduced due to the decrease in plasma volume brought on by the loss of fluids via sweat.⁸ This decrease in central blood volume also causes a reduction in the heart's stroke volume.^{7, 28} As stroke volume falls, HR increases in order to maintain cardiac output.^{7, 28} Reductions in stroke volume, and thus cardiac output, result in hypoxia of working tissues. Furthermore, the reduction of cardiac output is augmented especially if a high environmental temperature requires blood to be shunted away from the core and toward the skin for cooling purposes.⁷ Cardiac output is maintained at submaximal exercise intensities as increases in HR compensate for the decreased stroke volume. However, due to the increased HR, maximum HR is reached at a lesser exercise intensity, thereby limiting cardiac output.⁷ Additionally, since maximal cardiac output is reached at a lesser exercise intensity, aerobic capacity, and thus the work that can be performed, are also reduced.⁷ The amount of time it takes to reach exhaustion also decreases as environmental temperature increases.^{7, 10}

Acute Physiological Responses to Heat in Firefighters

Heart Rate

Firefighters demonstrate HRs between 80 and 208 bpm during maximal physical work and operational work training with mean peak HRs as high as 197 bpm.³ Bugajoka et al. reported mean maximum HRs as high as 164.2 ± 15.9 bpm during a simulated victim rescue.⁴ Firefighters operated at up to 96.2 ± 9.6 percent of their maximum HR while climbing ladders or stairs and carrying a hose during a simulated victim rescue outdoors with an ambient temperature of approximately 12°C .⁴ In another study, Smith et al. had firefighters complete drills, such as dragging a dummy, hoisting a hose, and chopping, for approximately 14 minutes, followed by a ten-minute rest period, and then working for an additional seven minutes. Heart rates rose to 189.3 ± 10.5 bpm during the second work period.⁶ This research indicates that firefighters work at near maximal HRs during much of their training, thus increasing their physiological strain.

Not only does the physical work completed by firefighters increase HR, but also the sounding of the fire alarm to signal the firefighters to answer a call. On average, firefighters' HRs increased 47 bpm 15 to 30 seconds after the alarm, and remained, on average, 30 beats higher at one minute post-alarm.⁵ The physical activity of preparing to answer a call after the alarm sounds accounted for 36 beats of those additional 47 at 15 to 30 seconds post-alarm, but for only nine beats at one minute post-alarm.⁵ Upon arrival at a fire, firefighters averaged a HR of 150 bpm.⁵

Body Temperature

Rectal temperatures as high as 41.4°C were recorded by Ilmarinen et al. in firefighters during physical work training for 1.5 hours indoors and outdoors.³

Additionally, training in a flashover facility for 25 to 30 minutes produced rectal temperatures up to 39.3°C and as high as 39.9°C during wintertime training in small burning houses for 10 to 30 minutes.³ Espinoza et al. measured GI temperatures in firefighters during two, successive 15-minute drill sessions followed by a 20-minute rest. Three percent of participants had peak GI temperatures above 40°C.³² Another eight percent exhibited peak GI temperatures between 39.4 and 40°C.³² Smith et al. measured rectal temperatures in firefighters during live-fire firefighting drills in a four-story building with fires on the second and fourth floors. Firefighters completed drills for approximately 18 minutes with a ten-minute rest period after about 12 minutes of drills. Rectal temperatures as high as 38.6°C were recorded.³³ Similarly, Griefahn et al. found rectal temperatures of 38.4°C in firefighters completing firefighting drills for approximately 15 minutes. In this case, however, there was no live fire, and ambient temperatures ranged from 11-25°C.³⁴ Taken together, these studies show that firefighters often work at elevated CBTs, which may contribute to increasing a firefighter's risk of developing an EHI.

Body Mass Loss

Espinoza et al. demonstrated that 53 percent of firefighters lost two to three percent of their body weight after two 15-minute drill sessions and a 20-minute rehabilitation period using one of four cooling methods: peripheral cooling, KoreKooler Rehab chairs, misting fans, or wet towels.³² Five percent of participants in the study lost more than three percent of their body weight.³² Those who lose more than three percent of their body weight during training will be at a greater risk of developing an EHI due to dehydration and may suffer a decrease in performance.

Urine Specific Gravity

In the same report by Espinoza et al., firefighters were evaluated prior to training. Twenty-two percent of participants were dehydrated prior to training with urine specific gravities between 1.020 and 1.030.³² Four percent demonstrated urine specific gravities greater than 1.030, indicating greater dehydration.³² Those with urine specific gravities greater than 1.020 may be at greater risk of developing an EHI due to dehydration.

Ratings of Perceived Exertion

Bugajoka et al. noted that firefighters reported RPE, on average, between 12.3 and 13.7, using Borg's 20 point RPE scale.⁴ Rating of perceived exertion increased from climbing a ladder, to climbing stairs with a hose, to rescuing a simulated victim.⁴ Smith et al. had firefighters complete drills for 14 minutes, followed immediately by a ten-minute rest period, another seven minutes of drills, and finally a 16-minute rest period. This set of work and rest was completed twice. Rating of perceived exertion increased both between and within sets, progressively increasing over each seven minutes of work.⁶

Acclimatization to Exercise in Heat

Although the body undergoes many acute responses to accommodate to exercise in the heat, chronic exposure results in acclimatization allowing the body to better perform in heat.^{7, 8, 10, 28} Acclimatization results in the ability to improve heat transfer from the body's core to the skin and to improve cardiovascular function, thus increasing one's ability to perform work.^{7, 8, 28} Approximately 10 to 14 days of successive exposure to continuous exercise for approximately 100 minutes²⁸ in heat is required for these changes to occur.^{8, 10} The first adaptations to occur include increased plasma volume⁷, reduced HR^{7, 28}, and adaptations of the autonomic nervous system enhance heat

dissipation.⁸ Core body and skin temperatures also are reduced.²⁸ Most of these changes occur within two to six days.^{8, 28} Perceived exertion also is reduced within the same timeframe due to early autonomic nervous system changes.^{7, 8} By the tenth day, most changes to support successful heat acclimatization have occurred, including a decrease in rectal temperature, as well as the renal and sweat concentrations of sodium and chloride.^{7, 8, 28} By day 14, sweat rate also has increased to allow for greater heat dissipation via evaporation.^{7, 8, 28} Additionally, sweating begins at a lower CBT to help attenuate the rise with exercise in the heat.²⁸ Currently, no literature is available regarding acclimatization specifically in firefighters.

Heat Illness

Exertional Heat Stroke

Exertional heat stroke occurs when the body's thermoregulatory system becomes overwhelmed by thermal stresses due to internal and external factors that exceed the body's ability to dissipate that heat.^{7, 10, 35} Exertional heat stroke can be triggered by intense exercise in a hot environment.³⁵ Exertional heat stroke is divided into three phases: the acute phase, the blood and enzyme phase, and the late phase.³⁵

The acute phase of exertional heat stroke occurs during the first hour after initial collapse, and is characterized by central nervous system dysfunction and hyperthermia (rectal temperature greater than 40°C¹⁰).^{11, 35} Central nervous system dysfunction can be identified by any of the following symptoms: altered consciousness, convulsions, irrational behavior, stupor, irritability, delirium, agitation, coma, etc.^{11, 35} Other signs and symptoms of exertional heat stroke may include hypotension, tachycardia, tachypnea, vomiting, diarrhea, and dehydration.^{8, 11, 35} Those suffering from exertional heat stroke

may also be sweaty and pale.¹⁰ The second phase of exertional heat stroke is known as the blood and enzyme phase. This occurs between one and 48 hours after the initial collapse.³⁵ During this phase, serum levels of various enzymes become elevated and blood disorders become recognizable.³⁵ During the late phase of exertional heat stroke, approximately 12-72 hours after the initial collapse, the function of the liver and kidneys begins to deteriorate.³⁵

With prompt recognition and treatment of exertional heat stroke, survival rate is 90-100 percent.^{35, 36} Treatment includes the prompt cooling of the individual via ice or cold water immersion, continued monitoring of CBT and vital signs, and transport to a hospital for definitive medical care once the patient is sufficiently cooled.^{8, 10, 11, 35}

Exertional Heat Exhaustion

Exertional heat exhaustion is characterized by the inability to continue exercising in the heat^{8, 10, 11} due to cardiac insufficiency.⁹ It is caused by a fluid-electrolyte imbalance during heat exposure.⁹ Individuals suffering from heat exhaustion may be distinguished from those suffering from exertional heat stroke by a moderately elevated CBT¹¹, absence of central nervous system dysfunction, and normal serum enzyme levels.⁹ They also may exhibit some of the following signs and symptoms: headache, weakness, dizziness, vertigo, heat sensations on the head or neck, nausea, vomiting, increased pulse rate, profuse sweating, syncope, low blood pressure, and mild cognitive impairment.^{7, 11} This usually occurs in unacclimatized individuals working at extremely high intensities who lose significant amounts of water and electrolytes via sweat.⁷

Cardiac insufficiency, the cause of exertional heat exhaustion, is due to water and/or salt depletion. Water depletion heat exhaustion is caused by water loss that is not

adequately replaced.⁹ Initially, this may be recognized by dry mouth, thirst, decreased urine volume, vague discomfort, anorexia, rapid pulse, impatience, weariness, sleepiness, and dizziness followed by tingling, dyspnea, cyanosis, and physical exhaustion.⁹ If severe dehydration is present, cognitive function, coordination, and the ability to stand may become impaired.⁹ Symptoms of water depletion heat exhaustion may be apparent within a few hours of exercise.⁹ Salt depletion heat exhaustion, however, requires three to five days before symptoms become apparent.⁹ This is typically caused by a low intake of dietary sodium or a large loss of sodium.⁹ Three progressive stages of salt depletion heat exhaustion exist, characterized by fatigue, followed by pallor, nausea, muscle cramps, and vomiting, and finally collapse, hypotension, and possible shock.⁹

Appropriate treatment for exertional heat exhaustion includes rehydration¹¹ by orally ingesting, if possible, a dilute electrolyte solution (0.1% NaCl).⁹ The patient also may be cooled for comfort by moving to the shade, lying supine with the feet elevated, and removing excessive or restrictive clothing, but rapid cooling is not necessary.^{9, 11}

Incidence of Exertional Heat Illnesses in Firefighters

Firefighters are often exposed to extremely high temperatures while physically exerting themselves to perform different tasks essential to extinguishing fires. This puts them at risk of increasing their CBT due to physical exertion, the protective clothing worn, and extremely high ambient temperatures. With increased CBT during physical exertion, firefighters have an increased risk of developing an EHI.

The National Fire Protection Association's Fire Analysis and Research Division tracks the injuries, illnesses, and fatalities of firefighters while on the job. Between 2003 and 2006, 2330 injuries were reported due to exhaustion or fatigue, including heat

exhaustion, as the primary symptom.¹² Five hundred and fifty of those injuries were considered moderate to severe and potentially life-threatening.¹² Symptoms of dizziness, fainting, weakness, dehydration, and nausea were also reported in over 1200 cases in the same report.¹² These symptoms may be indicative of various EHIs, and a portion of these additional complaints may potentially represent undiagnosed heat illnesses. The lack of specific data regarding EHIs experienced by firefighters due to occupational thermal heat stress indicates that further research is necessary to determine the incidence of specific EHIs.

In 2008, one fatality due to heat stroke was reported after a new volunteer firefighter died after participating in training exercises.¹³ This accounts for two percent of the deaths among volunteer firefighters.¹³ Forty-one deaths were reported due to overexertion/stress/related medical issues.¹³ Of those, four were due to stroke and one due to dehydration with an underlying hemoglobinopathy.¹³ The types of strokes suffered were not disclosed. Once again, the lack of detailed data may indicate a death due to an undiagnosed heat stroke. It also demonstrates the need for more data regarding the incidence of EHI in firefighters and perhaps for the education of firefighters and emergency medical services regarding prevention, recognition, and treatment of EHIs.

Prevention

Predisposing Factors to Heat Illness

The environment in which a firefighter works and the clothing required for protection contribute to the external factors predisposing one to the development of a heat illness. Firefighters are often exposed to extremely high environmental temperatures for prolonged periods of time while performing strenuous physical activity. Rossi et al.

demonstrated that environmental temperatures typically range from 40 – 190°C, with a maximum of 298°C during a heat flux, where the firefighters were training in a simulated live fire.¹ These extreme temperatures put firefighters at an increased risk of developing an EHI as these temperatures exceed skin temperature.^{11, 37} Once the environmental temperature exceeds the temperature of the skin, the body is unable to release heat via convection and radiation and is forced to rely mostly on evaporation. Humidity is often very high when extinguishing a fire since the black smoke turns to a white mist.¹ Increased humidity reduces the body's ability to release heat via evaporation, increasing the amount of heat stored in the body and thus increasing the risk of developing an EHI.

Radiant heat from the fire and reduced air motion due to the firefighters' protective clothing also contributes to this risk.^{11, 37} The protective clothing worn by firefighters also greatly reduces the amount of heat the body may lose by evaporation.^{11, 30, 37} With high environmental temperatures, high humidity, and protective clothing, the body's means of releasing heat are compromised, increasing the firefighters' risk of developing an EHI. Additionally, Armstrong et al. showed losses of sodium and calcium greater than the recommended daily intake in soldiers wearing uniforms for six hours.³⁸ Firefighters may be wearing similar types of uniforms while fighting fires and may also be at risk for loss of electrolytes, increasing their risk of EHI.

In addition to environmental factors predisposing firefighters to heat illness, many internal, or inherent, factors have the potential to do the same. Dehydration is a major inherent factor that may predispose a firefighter to developing an EHI.^{11, 37} The Orange County Fire Association assessed the hydration status via urine specific gravity of 101 of its firefighters in early August and reported that many were dehydrated before beginning

drills.³² Urine specific gravities of 1.020 to 1.030 were found in 22% of the firefighters and specific gravities greater than 1.030 were found in 4%.³² Considering that while firefighters are working, they may lose fluid via sweat, urine, and respiration and may not have the chance to replace the fluid, it can be dangerous for the firefighters to begin their work in an already dehydrated state. By not replacing those fluids appropriately, various levels of dehydration can occur.^{11, 37}

The same study noted that firefighters lost various amounts of body weight during firefighting activity.³² Drills during the study included 15 minutes of working in a live, simulated structural fire with persons trapped followed by another 15 minutes of work-related movements such as stair climbing and overhaul without their self-contained breathing apparatus (SCBA). Following this activity, 53% of firefighters lost 2-3% of their body weight and 5% lost over 3% of their body weight.³² Once a firefighter becomes dehydrated, performance and normal abilities of the thermoregulatory system suffer^{7, 37}, which increases heat storage and reduces time to exhaustion.¹⁰ Body weight water loss of 6-10% also can reduce one's tolerance of physical activity.¹⁰

Judelson et al. demonstrated that physical performance after completing six sets of back squats is reduced in 2.5 and 5% body water weight lost dehydrated individuals.³⁹ This physical activity may relate to firefighters' tasks since they also regularly perform repeated, intermittent resistance exercise. Therefore, firefighters should always begin activity in a euhydrated state and replace lost fluids during rest periods. By failing to stay hydrated, firefighters may therefore increase their risk of developing an EHI. Given the health and performance consequences of dehydration, firefighters should give attention to their hydration status to help reduce the risk of EHI.

Having a high body mass index, especially one above 22 kg/m²³⁷, also increases the risk of developing an EHI.^{11, 37} With a greater fat layer surrounding the body, less heat can be lost by the body, putting individuals at a greater risk of EHI.^{11, 37} Additionally, those who are obese produce greater metabolic heat and are less efficient at dissipating heat.^{11, 37} It is also important to be aware that despite the influence of body fat on predisposition to EHI, those who are muscular and carry a large lean body mass will produce greater metabolic heat.³⁷ In addition, those with a lower surface area to body mass ratio will have a decreased ability to dissipate the heat generated.³⁷ Increased metabolic heat production and decreased ability to dissipate heat cause one to developing an EHI.

Physical fitness plays a role in the prevention of EHIs as well.^{11, 37} Those who have poor physical fitness^{10, 11, 37} or are untrained have a greater risk of EHI.³⁷ Individuals practicing with a team can often overexert themselves to keep up, which may lead to higher CBTs, increasing the risk of EHI.³⁷ Overzealousness also can predispose one to developing an EHI.^{11, 37} One who is highly motivated to complete a task, keep up with teammates, or as in the case of a firefighter, rescue a victim from a burning building, may push his/her body beyond its physiological capabilities, increasing the risk of EHI.³⁷

Acclimatization to the heat and performing in hot temperatures can reduce the risk of developing an EHI.^{10, 37} Individuals who are less physically fit take longer to develop the adaptations to performing in a hot environment.³⁷ Without these adaptations, physiological strain while working in a hot environment will be increased, performance will suffer, and the risk of developing an EHI will be increased.³⁷

Many other factors such as recent illness, previous EHI, certain medicines (antihistamines and diuretics^{11, 37}), poor nutrition, electrolyte imbalance³⁷, and poor sleep duration and quality^{7, 37} also increase one's risk of developing a heat related illness.

Safety Protocols

Firefighters are repeatedly exposed to extreme temperatures and heat fluxes while performing the physical demands required of their job. With safety of the emergency personnel a priority, many reports have evaluated the conditions under which firefighters work and from that, many standards and guidelines have been developed with the safety of the firefighters in mind.^{15-19, 40, 41} However, although these guidelines exist, fire departments are not required to follow the standards, and they serve as only a suggestion.

The International Association of Fire Fighters (IAFF), an entity of the United States Fire Administration (USFA) and the Federal Emergency Management Agency (FEMA), has created one such safety protocol to focus on prevention of EHI. The IAFF produces the Emergency Incident Rehabilitation manual to address the management of heat stress in firefighters while working.⁴⁰ The recommendations found in this manual are based largely on the National Fire Protection Associations Standards 1582, 1583, and 1584. NFPA 1584 is the Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises.¹⁶ Within this standard, the NFPA states that standard operating guidelines for firefighter rehabilitation during incidents and training activities should be developed by fire departments. Methods of firefighter rehabilitation should include at least the following: relief, rest, and recovery; active and/or passive cooling; rehydration; calorie and electrolyte replacement; medical monitoring; EMS treatment based on local protocol; member accountability; and release.

The NFPA recommends that firefighters be educated on heat stress and follow the standards for fitness program. These standards also state that firefighters should maintain appropriate hydration, nutrition, and diet at all times to allow the body to function normally. If firefighters are aware of a scheduled event, such as a training session, they should drink 16 ounces of fluid two hours before the scheduled event.

When an emergency incident or training activity has the potential to become a health or safety risk to firefighters, the set-up of a rehabilitation area is indicated. It should be set up in the shade, provide a place to sit, and be distanced enough from the scene to allow for protective equipment to be removed safely. Fluids should always be available, as well as food and electrolyte solutions if indicated by the activity. An area for medical monitoring and treatments should be created as well as access to quick and convenient transport of an ill or injured firefighter to a hospital for definitive care. Emergency medical services retain the authority to oversee the rehabilitation, removal from activity, and transport of ill or injured firefighters.¹⁶

The NFPA suggests that firefighters undergo rehabilitation after the use of a second 30-minute SCBA cylinder, one 45-minute or 60-minute cylinder, or after 40 minutes of intense work without SCBA. The first rehabilitation period must be at least ten minutes but should be longer, if possible.¹⁶ The standards, however, represent the minimums for rehabilitation. Ideally, the NFPA recommends relief from duty or rehabilitation following the use of one 30-minute SCBA cylinder or 20 minutes of intense work without SCBA.

The IAFF's Thermal Heat Stress Protocol recommends that 30-minutes rest/rehabilitation periods should follow each 30 minutes of work.¹⁸ During rehabilitation,

the NFPA suggests that firefighters remove protective gear, drink fluids to satisfy thirst, and use cooling when they feel warm or hot. During incidents longer than three hours or when working for more than one hour, firefighters should also replace calories and electrolytes.¹⁶

Minimally, basic life support emergency medical services should be available and be cognizant of firefighters complaining of chest pain, dizziness, shortness of breath, weakness, nausea, headache, cramps, aches, pains, heat/cold stress, change in gain, speech, or behavior, are not alert and oriented to person, time, place, and thing, or abnormal vital signs as established by local protocol.¹⁶ Following rehabilitation, firefighters should not return to activity if they do not feel rested, display medical, psychological, or emotional distress, or display some other action indicating that their return to the incident would be unsafe.¹⁶

The IAFF also produces the Thermal Stress Protocol, which urges firefighters to maintain an appropriate hydration status and wear cotton garments underneath their protective clothing to aid cooling. It recommends that firefighters work in cycles of 30 minutes of work followed by 30 minutes of rest to recover for the next work cycle. Before re-entering the structure, firefighters should have their HR, blood pressure, and CBT evaluated; however, the protocol does not indicate that this temperature should be obtained rectally. If a firefighter's HR exceeds 75% of his or her age-adjusted maximum, he or she should reduce the next work cycle by one-third. During rest periods, firefighters should relax and rehydrate by drinking cool fluids, at least 8 ounces every 15 minutes. If the apparent temperature exceeds 32°C, as indicated by the Steadman Apparent Temperature Index, training activities should be monitored closely. Activity should be

modified or suspended when the apparent temperature exceeds 40°C, taking into account an additional 2°C above the air temperature for exposure to direct sunlight or for wearing protective clothing.¹⁸

The Occupational Safety and Health Administration (OSHA) created the OSHA Technical Manual with a section on dealing with heat stress. This section educates on EHI and the various effects thermal stress can have on one's health as well as guidelines for work practices in the heat.¹⁹ OSHA suggests assessing work-load to use in combination with wet-bulb globe temperature adjusted by clothing type to determine work/rest ratios per hour. Assuming firefighter work would fall under moderate and heavy workload categories, continuous work can be performed below 26.7 and 25°C, respectively. At higher temperatures, work/rest ratios evolve to 75%work to 25% rest, 50% work to 50% rest, and 25% work to 75% rest each hour. Additionally, the manual encourages proper heat acclimatization for those in warm climates by exposing the worker to hot temperatures for progressively longer periods of time beginning at 50% exposure and increasing daily by 10%. Appropriate fluid replacement with cool liquids (except alcoholic beverages) at 50-60°F by drinking one cup every 20 minutes is suggested. Engineering controls such as general ventilation, air conditioning, local air-cooling with blowers or fans, or shields also may alleviate some heat stress. Good work practices that include education of all workers on heat stress and its management with particular focus on warning signs, treatment, prevention, risk factors, use of protective equipment, and participation in medical surveillance programs.

OSHA also advocates the use of worker monitoring programs by encouraging workers to check their HR, recovery HR, oral temperature, and body mass loss.

Unfortunately, oral temperature is not a valid means of assessing CBT in the heat, and should not be relied on as an accurate measure of CBT. Rectal or GI temperature should be used to determine CBT. However, their suggestion to reduce the next work cycle by one-third with a temperature greater than 37.6°C may be conservative enough to benefit a working firefighter. OSHA also suggests reducing the following work cycle by one-third if the HR exceeds 110 bpm at the beginning of the rest period. Additionally, recovery HR should be monitored at 30 seconds and 2.5 minutes into the rest period. If the difference in HR between those times is ten or greater, satisfactory or better recovery is being achieved. Also, body mass loss should be monitored at the start and finish of the workday. Losses exceeding 1.5% total body weight indicate increased fluid intake.

Administrative controls are also recommended for the health and safety of workers performing in the heat. OSHA suggests reducing physical demands of work, providing rehabilitation and recovery, working during the coolest parts of the day, allowing rest periods and water breaks, using relief workers and worker pacing, and increasing or decreasing the number of workers according to the space available on the job. Some of these controls, however, are difficult to apply to firefighters. The most beneficial to firefighters may be providing rest and recovery, water breaks, and using relief workers. The use of auxiliary body cooling devices may also relieve some heat stress in firefighters. OSHA specifically mentions the use of ice vests, wetted clothing, water-cooled garments, and circulating air. Many other cooling devices may be practical for use by firefighters, including fans, misting, forearm and hand immersion, and the focus of this study, head cooling.

OSHA created National Institute for Occupational Safety and Health (NIOSH) located within the Centers for Disease Control and Prevention (CDC) under the United States Department of Health and Human Services. NIOSH is not a regulatory agency, but functions to provide research, education, and training to encourage safe working environments. NIOSH Publication No. 86-112 discusses working in hot environments, but does not address firefighting specifically. This publication focuses on education of the body's physiology when exposed to heat, potential health threats including heat illnesses, and how to prepare for the heat and prevent illness. In preparing for a job in the heat, they suggest acclimatizing over five to seven days. This may be a prominent factor for firefighters extinguishing fires in hot environmental temperatures in addition to the heat produced by the fire. To reduce thermal stress, the NIOSH recommends reducing the number or durations of exposure to heat, using fans and ventilation when possible, and providing rest and fluids for rehydration.¹⁷

Beyond what government organizations have produced to address the safety of those working in hot environments, two researchers for the Toronto Fire Service produced a report and review article regarding the management of heat stress, specifically in firefighters.^{15, 41} Studies they conducted led to the development of recommendations for establishing safe work limits and reducing heat stress. This compilation of research demonstrated that exercise tolerance time depended on workload and environmental conditions.¹⁵ This led to the development of the Heat Stress Wheel, which combines the environmental temperature with relative humidity to categorize heat stress and serve as a guide by which to modify activity appropriately. Their studies have also shown that passive cooling results in a continued rise in CBT during rest periods.¹⁵ Additionally, it

was concluded that wearing shorts under protective equipment rather than pants increased exercise tolerance time when greater than 60 minutes and showed significantly reduced time loss due to heat exhaustion when shorts were worn.¹⁵ Appropriate hydration allowed tolerance of a higher rectal temperature during exercise, and forearm and hand submersion during rest periods provided the most efficient cooling, allowing increased exercise tolerance time, compared to passive cooling and the mister.¹⁵ Therefore, particular attention should be paid to the environmental temperature and relative humidity to modify work practices. Firefighters should also be encouraged to wear shorts under protective equipment and maintain an appropriate hydration status during and post-incident. During rest periods, hand and forearm cooling is an effective means of active cooling to help rehabilitate firefighters.

Cooling

Treatment Cooling

Cold-water immersion is currently considered the standard treatment for exertional heat stroke.^{36, 42, 43} This treatment of exertional heat stroke is supported by both the National Athletic Trainers' Association¹¹ and the American College of Sports Medicine.¹⁰ Research has suggested that the severity of exertional heat stroke is reduced if the amount of time the body's core temperature remains above 40°C is reduced.⁴² With the use of cold water immersion, CBT can be reduced below 40°C very quickly; therefore, the amount of organ damage sustained due to the elevated CBT is reduced.⁴³

Preventative Cooling

Based on this treatment, many different methods of cooling have been developed and explored to help facilitate the attenuation of the rise of CBT in active individuals,

especially during exercise in the heat. These cooling methods have been explored for the purpose of both performance and prevention of EHI by cooling the body or specific parts of the body before activity, during activity, during rest pauses between bouts of exercise, and as treatment for an existing EHI.

Precooling

Cooling the body prior to exercise for the purpose of enhancing performance has been explored.⁴⁴⁻⁴⁶ Arngrimsson et al. demonstrated that runners who wore ice vests during a 38 minute warm up attenuated the rise in body and skin temperature, HR, and their perception of thermal discomfort at the beginning of a five kilometer race.⁴⁴ Those who precooled with ice vests ran the race in a statistically significant lower time and at a faster pace, most evident in the last two-thirds of the race.⁴⁴ Lee et al. pre-cooled participants by resting in thermoneutral or cold (5°C) air. Both groups of participants then rested in room temperature air before running to exhaustion in thermoneutral conditions. Participants who were precooled demonstrated a greater time to exhaustion than those who were not. Rectal temperature in precooled subjects was significantly lower for 25 minutes of running.⁴⁵ In a study by White et al, participants were cooled by either lower body or whole body immersion in 20°C water prior to cycling 30 minutes at 60% $\text{VO}_{2\text{max}}$. Those who underwent whole body immersion precooling had significantly lower rectal temperatures for the first 24 minutes of cycling.⁴⁷

Although some studies have shown enhanced exercise performance with precooling, Bolster et al. explored the effects of precooling on attenuation of physiological variables and performance in swimming followed by biking, similar to the

format of a triathlon. This study, however, found no significant effects on physiological or subjective variables, offering no performance advantage in this scenario.⁴⁶

Cooling between Bouts of Activity

Cooling between bouts of physical activity has also been researched.⁴⁸ Yeargin et al. had participants run for 90 minutes. Then, they were treated with cold water, ice water, and no water immersion over three separate trials. Following each immersion, they ran a two-mile race. Cold and ice water immersion of participants resulted in significantly lower rectal temperatures at the end of the two mile race and improved performance during the race.⁴⁸ This decrease in rectal temperatures allows the body to maintain a lower rectal temperature for a longer period of time before reaching a critical level .

Cooling between bouts of exercise has also been explored in firefighters specifically.²¹ Firefighters completed two cycles of 10 minutes of work followed by ten minutes of rest. During rest, subjects either unbuckled their coat or removed it and rested in front of a fan. In those who rested with the fan, HR reached baseline in less time and was not as high as the control group in the second set. Rectal temperature and arm, chest, and thigh skin temperatures were also reduced in the fan group. Participants resting with a fan also lost significantly less fluid compared to the control group.²¹

Cooling during Activity

Vests fitted with ice packs or special cooling materials have been explored regarding attenuation of rise in CBT. Firefighters benefitted from the use of cool vests during activity for the attenuation of CBT and PTS.^{20, 49} While wearing a phase change material cool vest and cycling for 30 minutes at 55% VO₂ max, the increase in rectal temperature was attenuated compared to control and ice vest participants.⁴⁹ Additionally,

the participants in the control condition felt significantly hotter than in the cool vest conditions.⁴⁹ Firefighters also completed two live fire drills while wearing or not wearing cool vests. Those who wore the cool vest had a significantly lower rectal temperature of $38.6 \pm 0.3^{\circ}\text{C}$, compared to $39.3 \pm 0.8^{\circ}\text{C}$ in the control group, and significantly lower perceived thermal sensation of 4.4 ± 0.9 , versus 5.5 ± 1.3 in the control group, after completing each drill.²⁰

Cooling of the hands and forearms between bouts of activity has also been successful in attenuating the rise of physiological variables in firefighters.^{22, 23} Giesbrecht et al. instructed firefighters to complete 20 minutes of work (stepping) in full firefighter gear followed by 20 minutes of rest, three times. Aural canal temperature by thermal couple to the tympanic membrane was used to determine CBT. Cooling during rest periods consisted of immersing hands in 10 or 20°C water, immersing hands and forearms in 10 or 20°C water, and the control condition with no accessory cooling. Cooling the hands and forearms in 10°C water during rest periods resulted in significantly lower CBTs compared to all conditions after the second and third rest/cooling periods.²² Additionally, CBT at the completion of the protocol in this condition was not significantly higher than the baseline temperature, indicating that hand and forearm cooling at 10°C is a viable method of attenuating the rise in CBT in firefighters.²²

In another study by Selkirk et al., firefighters wore all typical firefighting gear and a breathing apparatus in a 35°C and 50% relative humidity environmental chamber while walking on a treadmill at 4.5 km/h for 20 minutes. This was followed by walking at a slower pace and standing for 10 minutes to simulate a cylinder exchange, then another 20

minutes of walking at 4.5 km/h, and finally a 30 minute rest phase. During the rest phase, firefighters submerged their forearms in approximately 17.4°C water. This resulted in significantly greater reductions in rectal temperature compared to passive cooling.²³

Many studies have investigated the effects of different means of head cooling, some by cooling the head and neck with a “cap” or gel pack inside of a hat and others via a fan and mist with equivocal results. Most have found no significant reduction in rectal temperature.^{24-26, 50} Fujii et al. explored the effects of pouring 2 liters of non-refrigerated water over the head and hands. Participants cycled for 20 minutes in a 35°C/60% relative humidity environmental chamber then had 15 minutes of rest. At the beginning of the rest period, participants had the water poured over their head while they rubbed their head with both hands. This had no significant effect on reducing rectal temperature or HR.⁵⁰ However, head wash cooling did significantly improve the participants’ perception of alertness, concentration capacity, equilibrium, and tiredness.⁵⁰

Simmons et al. investigated the effect of head and neck cooling on high core temperature. Subjects were passively heated in a 45°C/50% relative humidity environmental chamber until their rectal temperature increased 1°C. Two trials were performed, one with head cooling via a liquid conditioned balaclava perfused with 8°C water and one without cooling. Head cooling in this study significantly attenuated the time for rectal temperature to increase 1°C.²⁵ During the head cooling condition, the increase of 1°C in rectal temperature took 101±4 minutes, while no head cooling took only 94±5 minutes.²⁵ It also significantly improved the perception of thermal comfort.²⁵

In another study, Choi et al. studied the effect of head cooling by gel pack inside of a hat during simulated red pepper harvesting in an environmental chamber (WBGT

33°C) for two hours. Head cooling in this study showed no significant effect on the attenuation of rectal temperature, HR, or PSI.²⁴

Wickwire et al. explore the effects of a gel pack worn inside of a ballistics helmet during light exercise in a 35°C/38% relative humidity environmental chamber.

Participants walked on a treadmill at 4.8 km/h for two hours with 3 minute breaks every 12-15 minutes. During breaks, 10 bicep curls were performed. This study found no significant differences in rectal temperature, HR, RPE, or thermal strain rating.²⁶

While many studies found rectal temperature to decrease due to accessory cooling, Ansley et al. found that rectal temperatures during head cooling, by means of a fan and mist of water, tended to be higher compared to no cooling.⁵¹ In this study, participants cycled at 75% of their VO₂max until volitional fatigue under conditions of head cooling and no head cooling. Head cooling resulted in a significantly greater time to fatigue and significantly lower RPE based on the Borg scale.⁵¹

Conclusion

In conclusion, firefighters store enough heat in their body to raise their CBTs. This, as well as many other factors, puts them at risk of developing an EHI. Due to this risk, studying ways to attenuate the rise in CBT is necessary to prevent EHI in firefighters. Therefore, the purpose of this study is to investigate the physiological and perceived effects of head cooling in firefighters during simulated firefighting activity.

CHAPTER 3

METHODS

The study was a randomized, control group design. The independent variable was cooling with two levels: gel pack head cooling and no cooling. The experimental group wore the GelCool gel pack head cooling device while completing simulated firefighting tasks. The control group did not wear the head cooling device while completing simulated firefighting tasks. Dependent variables included physiological responses in HR, GI temperature, PSI score, body mass loss, sweat loss, sweat rate, urine specific gravity, and cognitive function determined by the Stroop Test interference score, and perceptual responses in RPE and PTS.

Participants

Forty-one career firefighters from the Terre Haute Fire Department in Terre Haute, Indiana volunteered to participate in the study after an informative presentation by the researchers. Twelve firefighters were randomly assigned to an experimental group outside of this study. Two firefighters voluntarily withdrew from the study before data collection. The remaining 26 firefighters (40 ± 8 y; 168 ± 7 cm; 91.8 ± 14.2 kg; 51.8 ± 7.6 ml/kg/min) were randomly assigned to the control and experimental groups of this study. Two firefighters did not complete the second half of the protocol. Six firefighters had unusable data due to the failure of the ingestible thermistor to travel far enough into the

intestine. Two participants were allowed to participate in the study but were excluded from inclusion in any variables related to heart rate as a result of taking medication for cardiovascular disease.

Participants completed their pre-participation physical required by the fire company for occupational duties and had it on file with the fire department. Participants were in good health; this was demonstrated by his ability to participate in any and all tasks related to the occupation without accommodation or restriction. Participants were excluded if they had work-related accommodations or restrictions. If participants had a cardiovascular disease and/or took beta- blocker medication, they were excluded from data analysis for heart rate related variables. All participants were informed of the experimental protocol, risks and benefits associated with participation, and how the researchers maintain each subject's privacy and confidentiality. The researchers also informed the participants of what was expected of their participation and provided them the opportunity to ask questions. Each participant signed an informed consent form.

Measurements and Instrumentation

Gastrointestinal Temperature

The CorTemp Ingestible Core Body Temperature Sensor (HT150002; HQ Inc., Palmetto, FL) measured GI temperature and was displayed on the CorTemp Data Recorder (HT150016; HQ Inc., Palmetto, FL) operated by the researchers. Participants swallowed the ingestible sensor with water approximately five hours before the beginning of data collection. The pill travels through the GI tract without disturbing normal body functions and typically passes within 12-48 hours, although this time may vary between individuals. The ingestible sensor was activated once it was removed from

its packaging. Once activated, it began to transmit a signal to the data recorder. GI temperature indicated a participant's core body temperature and was monitored throughout the training protocol for safety purposes.

Heart Rate

A heart rate strap (T31-non-coded; Polar Electro, New Hyde Park, NY) worn around the participant's chest inferior to the pectoral region measured HR and sent a signal to a watch worn by the researchers that displayed HR. HR indicated how fast the participant's heart was beating throughout the protocol and is useful in measurements of physiological strain due to heat. Additionally, HR was monitored for safety purposes throughout the training protocol.

Physiological Strain Index

The Physiological Strain Index (PSI) rates physiological strain due to heat on a zero to ten scale; it is calculated based on rectal temperature between 36.5 and 39.5°C and HR between 60 and 180 bpm. PSI was calculated with the following formula: $PSI = 5(T_{ret} - T_{re0}) \cdot (39.5 - T_{re0})^{-1} + 5(HR_t - HR_0) \cdot (180 - HR_0)^{-1}$, where T_{ret} and HR_t were simultaneous measurements taken at any time during the exposure for rectal temperature and HR, respectively, and T_{re0} and HR_0 were the initial measurements of rectal temperature and HR, respectively. A PSI score of 0 represents no/little heat strain, while 10 represents very high heat strain.⁵²

Body Mass Loss

Body mass (BM) was measured by a scale (BWB-800; Tanita, Arlington Heights, IL) before and after the experimental protocol. Body mass loss (BML) due to the training protocol was calculated with the following formula: $BML(\%) = [(BM_0 - BM_f) \cdot BM_0^{-1}] \cdot$

100, where BM_0 was the initial body mass and BM_f was the final body mass following the experimental protocol.⁵³ To measure BM, participants stepped on the scale wearing only shorts. The researchers recorded the BM in kilograms. Body mass loss was calculated to determine hydration status and for safety purposes. Losses of even one to two percent can negatively impact physiological function and performance, while a loss of more than three percent of body mass also increases the risk of developing an EHI.⁵³

Sweat Loss

The researchers calculated sweat loss for each participant to determine the amount of sweat lost due to the experimental protocol by considering the pre- and post-exercise body mass, the amount of fluid consumed in milliliters, and the amount of urine output in milliliters. It was calculated with the following formula: $SL = (BM_0 - BM_f) + \text{fluid intake} - \text{urine output}$. Sweat loss was calculated to determine hydration status.

Sweat Rate

The researchers calculated sweat rate for each participant to determine the rate at which they lost sweat during the experimental protocol based on the same formula as sweat loss with a time component in hours. It was calculated with the following formula: $SR = [(BM_0 - BM_f) + \text{fluid intake} - \text{urine output}] / \text{time}$.⁵³ Sweat rate was calculated for descriptive purposes and to provide personal data to each participant.

Urine Specific Gravity

A refractometer (Model A300CL; ATAGO Inc., Bellevue, WA) measured the density of the particles in the urine compared to pure water; this is an indication of hydration status and was measured for safety purposes.⁵³ A refractometer was chosen to assess hydration status because it is less subjective than referring to a urine color chart.

Urine specific gravity (USG) greater than 1.020 were considered dehydrated, while those equal to or less than 1.020 were considered hydrated.^{11, 53}

Rating of Perceived Exertion

A numbered scale from six to 20 served as an index of how easy or difficult one perceived their work.⁵⁴ The researchers showed the participants a visual representation of this numbered scale with descriptions and asked participants to rate their level of perceived exertion based on how hard they felt they were working; the researchers recorded this number.

Perceived Thermal Strain

Perceived thermal strain was measured on a scale of zero to eight, ranging from unbearably cold to unbearably hot, respectively.⁵⁵ The researchers showed the participants a visual representation of the numbered scale with descriptions and asked the participants to describe their thermal perception in number based on the corresponding written descriptions. The researchers recorded this number.

Cognitive Function- Stroop Test

The Stroop test is a paper test in which cognitive flexibility is assessed. This test was chosen to evaluate how well a firefighter can concentrate on a given task with interference. In this test, there were three parts, each lasting 45 seconds. Participants saw a series of color words written in black ink. They read the name of the color aloud, and the researchers recorded the number of words read. They then saw a series of XXXX's printed in different colors. Participants named the color in which the symbol was printed aloud, and the researchers recorded the number of colors stated in 45 seconds. These first two sections of the test served as baseline measurements. Then, the participants were saw

a series of words written in a conflicting ink color and were asked to say aloud the color ink in which the word was printed and instructed not to read the word written. The researchers recorded the number of colors stated in 45 seconds. This demonstrated the participants' ability to overcome the interference of the desire to read the written word and say only the color in which the word is printed. The number of words read in the incongruent color condition (conflicting colors) was subtracted from the congruent color condition (colored XXXX's). A lower score represents better performance and thus greater ability to resist the interference, whereas a higher score indicates a lesser ability to resist the interference.⁵⁶ This score was recorded to describe cognitive flexibility and demonstrate how well the firefighters' brain functioned with respect to an interference task throughout the training protocol.

Procedures

Day One

Participants arrived at the firehouse. The researchers briefed the participants on the schedule for the day and the study. The researchers informed the participants that the purpose of this study was to assess the effectiveness of an auxiliary head cooling device worn inside the helmet, intended for use by firefighters during activity. Researchers informed the participants of the measures and means of instrumentation and the experimental protocol they were expected to complete as a participant of the study. Researchers also informed participants that they may withdraw from the study at any time and that their participation in the study is completely voluntary. The researchers allowed the participants to ask any questions they had about the study or their participation in the study. After all of their questions were answered, those who chose to

participate completed a health history questionnaire, a current health questionnaire, and the informed consent document. After the appropriate paperwork was completed, the participants completed the Queens College Step test to estimate oxygen consumption.⁵⁷

Day Two

The researchers arrived at the fire stations five hours prior to the training session to meet the participants. At this time, the participants completed a current health questionnaire, which was reviewed by the researchers. If the participant was found to be in good current health, the researchers activated the ingestible temperature sensor, and the participants swallowed the capsule. At their scheduled time, participants arrived at the testing facility. Upon arrival, the researchers made sure the pill was functional by taking a baseline reading. Participants picked whether they would be in the experimental or control group by blindly picking a marked ping-pong ball out of a box as well as a marked ping-pong ball to determine at which drill they would begin the training protocol. Participants then provided a urine sample in order to assess urine specific gravity. Participants stepped on a scale wearing only shorts, and the researchers recorded pre-training session body mass. Participants adorned the HR monitor with help from the researchers. Researchers made sure the HR strap was functional and reporting data to the watch and recorded the heart rate.

After obtaining these baseline measurements, participants adorned their trousers and jackets. The baseline Stroop test was administered by the researchers and baseline RPE and PTS were recorded. Following this, the firefighters adorned their remaining gear including hoods, gloves, helmets, and self-contained breathing apparatus (23.3 ± 1.4 kg). Those in the experimental group also adorned the head cooling gel pack by removing it

from the freezer and securing it in the top of the helmet. The researchers recorded GI temperature and HR, and the participants began the experimental protocol. Participants completed four drills determined by the Training Officer for 15 minutes. The participants' starting points in the drill sequence was chosen at random. The drills included an obstacle course, a high-rise drill, a search and rescue drill, and vehicle extrication. During the obstacle course, the firefighters crawled by following a hose on the ground over and through props and by carrying Rescue Randy. During the high-rise drill, the firefighters carried an appliance kit or a hose up four flights of stairs to the top of the training structure. They touched the pipe on that floor and then returned to the bottom floor. The tower was filled with smoke during this drill. The search and rescue consisted of the firefighters following a hose through a smoke-filled 2-story residence and crawling through props and up and down steps. During the vehicle extrication drill, the firefighters cut apart vehicles as they would in an emergency to extricate a victim.

During the 15-minute drills, the researchers recorded GI temperature and HR every three minutes. Following the drill, the participants exited the training facility or drill area, and the researchers recorded the GI temperature, HR, RPE, PTS, and Stroop test (part three) score for each participant. Participants replaced their air cylinder, and in the case of the experimental group, also replaced the head cooling gel pack. This exchange lasted $8:31 \pm 1:30$. The researchers recorded the GI temperature and HR before the participants re-entered the structure or drill area to complete drills for another 15 minutes. During this time, the researchers recorded each participant's GI temperature and HR at three-minute intervals. Following the 15 minutes of work, the participants exited the training structure and drill areas. Researchers recorded GI temperature, HR, RPE,

PTS, and Stroop test score. The participants removed their helmet, hood, SCBA, gloves, and jacket and lowered their trousers to rest in the rehab facility (a shaded area with picnic benches) for 15 minutes while drinking water ad libitum. Researchers continued to record GI temperature and HR at three-minute intervals during the rest period. Each participant had his own water bottle to drink from so that the volume of fluid consumed could be recorded. Nearing the end of the 15-minute rest, the researchers recorded the participants' GI temperature, HR, RPE, PTS, and Stroop test score. The participants re-dressed and re-entered the structure and drill areas to complete a second cycle of working for 15 minutes, exchanging cylinders, working for another 15 minutes, and resting for 15 minutes. At the end of the second rest period, the researchers recorded the participants' GI temperature, HR, RPE, PTS, and Stroop test score. The entire training protocol lasted 1:57:47±0:19. Participants then provided a second urine sample and stepped on a scale wearing only shorts for the researchers to record post-training body mass.

Statistical Analysis

Descriptive statistics were calculated for each variable. Independent samples t tests compared groups by demographics and hydration status. A repeated measures one-way analysis of variance (ANOVA) analyzed group (HC vs. CON) by time (baseline [BSLN], end drill one [D1], end drill two [D2], end rehab one [R1], end drill three [D3], end drill four [D4], end rehab two [R2]) for T_{GI} , HR, SIS, RPE, and PTS. When sphericity was not assumed, a Huynh-Feldt adjustment was used. If interactions were deemed significant by the ANOVA, paired t-tests were used for post-hoc analyses. A correlation analyzed the relationship between T_{GI} and PTS. Significance was set a priori at $p < 0.05$.

CHAPTER 4

MANUSCRIPT

Physiological and perceived effects of head cooling during simulated firefighting activity

Introduction

Firefighters must tolerate a variety of physiological stressors while on the job. They must repeatedly enter burning buildings with temperatures as high as 278°C¹ and sustain long periods of physical exertion^{2, 3}. Further, they must complete this task while wearing heavy protective clothing and a self-contained breathing apparatus (SCBA). The combination of reduced body surface area for dissipating heat due to protective clothing⁴, increased ambient temperature, and physical exertion forces firefighters' core body temperatures (CBT) to increase.⁵⁻⁸ As firefighters work to extinguish a fire, heart rate (HR) also increases^{2, 3, 5, 9} resulting in increased physiological strain.¹⁰ As physiological strain rises, firefighters also perceive that they feel hotter and as though they are working harder³

As the body stores heat, CBT continues to rise, which increases the risk of developing an exertional heat illness (EHI).¹¹⁻¹⁵ In addition to elevated CBT, the ambient temperature, humidity, intensity of work, length of exposure, protective equipment, hydration status, illness, and lack of sleep may also contribute to the development of an EHI.¹²⁻¹⁵ Exertional heat illnesses¹⁶⁻¹⁸ and fatalities resulting from EHI^{17, 18} are often

reported in firefighters on the job. In order to protect firefighters from adverse events, including EHI, several safety procedures exist.¹⁹⁻²³ Accessory cooling devices and protocols, including ice vests²⁴, fan²⁵ water mists²⁶, and forearm cold-water immersion^{26, 27} have also been investigated as a means of protecting firefighters from a dangerous rise in CBT.

Head cooling is one method that has been studied in various settings and at different levels of activity²⁸⁻³¹, but never in firefighters with their unique physical demands. It is unknown whether head cooling in firefighters attenuates the rise in core body temperature. Therefore, the purpose of this study was to investigate the physiological and perceived effects of head cooling in firefighters during simulated firefighting activity.

Methods

The study was a randomized control group design exploring the effects of head cooling (HC) versus no head cooling (CON) in firefighters during drills. Physiological variables included gastrointestinal temperature (T_{GI}), HR, Physiological Strain Index score (PSI), hydration status, and Stroop test interference score (SIS). Perceptual measures were also recorded and analyzed and included rating of perceived exertion (RPE) and perceived thermal sensation (PTS).

Participants

Twenty-six career firefighters (male, 40 ± 8 y, 168 ± 7 cm, 91.8 ± 14.2 kg, 51.81 ± 7.61 ml/kg/min) volunteered to participate in the study. At times throughout the protocol, not all participants were included in data analyses ($n=10$) as two were unable to complete the entire training protocol, six had unusable temperature data due to failure of

the ingestible thermistor to travel far enough into the intestine, and two took a medicine that altered HR. All participants had a medical physical on file with the fire department indicating that they were fit for work and medically cleared to use a SCBA without accommodation or restriction. Having a scheduled MRI, a gastrointestinal illness or pathology, and/or trouble swallowing large pills were considered contraindications to ingesting the thermistors; those with contraindications to the ingestible thermistor were excluded from participation. All participants were informed of the experimental protocol and expectations of participants, risks and benefits associated with participation, and how the researchers maintain participant privacy and confidentiality. After the participants had all of their questions answered, each participant signed an informed consent form. The university's Institutional Review Board approved the experimental protocol.

Instrumentation

Environmental Conditions and Demographics

The wet bulb globe temperature (Metrosonics HS-32 area heat stress monitor; Quest Technologies, Oconomowoc, WI) was measured at least once each hour so that any differences between shifts and days could be detected. Self-reported age was recorded; height was measured using a standard tape measure fixed to a wall. Aerobic capacity was estimated using the Queen's College Step Test.³²

Hydration Status

Hydration status was represented by urine specific gravity (USG), percent dehydration, and sweat loss. Each firefighter's pre-training and post-training USG was read using a handheld clinical refractometer (A300CL; ATAGO Inc., Bellevue, WA) to determine hydration status. Also, pre-training and post-training body masses of each

firefighter were measured using a scale (BWB-800; Tanita, Arlington Heights, IL) to calculate percent dehydration by body mass loss using the following formula: $((\text{pre-training body mass} - \text{post-training body mass}) * 100)$.³³ Firefighters were measured wearing only the shorts or pants they would be wearing under their personal protective equipment during the training protocol. Sweat loss was calculated with the following formula: $[(\text{pre-training body mass} - \text{post-training body mass}) + \text{fluid consumed} - \text{urine output}]$.³³ The volumes of fluid consumed and urine void were also recorded.

Gastrointestinal Temperature and Heart Rate

Gastrointestinal temperature was measured by the CorTemp ingestible thermistor (HT150002; HQ Inc., Palmetto, FL), which transmitted a signal to a handheld data receiver (HT150016; HQ Inc., Palmetto, FL) that displayed the temperature. Ingestible thermistors were distributed to firefighters after arrival at their station for their shift and were ingested five hours prior to their arrival time at the training facility. Heart rate straps (T31-noncoded; Polar Electro, New Hyde Park, NY) worn by firefighters sent a signal to the watch worn by the researchers and to the handheld data receiver. From the data displayed on the handheld data receiver and watch, researchers recorded T_{GI} and HR at three-minute intervals during the training protocol. Following data collection, PSI scores were calculated with the following formula: $PSI = 5(T_{GI_t} - T_{GI_0}) \cdot (39.5 - T_{GI_0})^{-1} + 5(HR_t - HR_0) \cdot (180 - HR_0)^{-1}$, where T_{GI_t} and HR_t were simultaneous measurements taken at any time during the exposure for T_{GI} and HR, respectively, and T_{GI_0} and HR_0 were the initial measurements of T_{GI} and HR, respectively. A PSI score can range from zero to ten; a score of one represents no/little heat strain, five represents moderate strain, and nine represents very high heat strain.³⁴

Cognitive Function

A modified version of the Stroop Color Word Test was administered to firefighters to assess cognitive flexibility.³⁵ The test consisted of three sections, each lasting 45 seconds. During the first section, firefighters were shown color words printed in black ink and instructed to read the word they saw. The second section consisted of a series of “XXXX XXXX” printed in various colors. The firefighters were instructed to say aloud the color they saw. During the third section, the firefighters were shown color words printed in a conflicting ink color and were instructed to say aloud the color in which the word was printed and not the word they read. The researchers recorded the number of colors correctly stated in each section. The interference score was calculated by subtracting the number of conflicting colors (section 3) stated from the number of visual colors (section 2) stated. A higher score indicated decreased test performance by stating fewer conflicting colors compared to visual colors, while a lower score indicated improved test performance by stating more conflicting colors.

Perceptual Measures

Firefighters were shown a visual scale numbered from 6 to 20 with descriptions and indicated the number that represented their rating of perceived exertion³⁶ at the conclusion of the station. For PTS, a visual scale numbered from 0 to 8 with descriptions was shown to firefighters, who indicated how hot or cold they felt at the time based on the scale descriptions.³⁷

Training Protocol

The training protocol included four 15-minute firefighting drills, including an obstacle course, high-rise drill, two-story search and rescue drill, and car extrication.

Firefighters randomly picked their starting point within the drill sequence by choosing a letter out of a box; the letter corresponded to the drill at which they would begin the training protocol. During the outdoor obstacle course, firefighters crawled on their hands and knees while following along a hose on the ground over and through various props and then used an armpit drag to move I.A.F.F. Rescue Randy (Simulaids, Inc., Saugerties, NY). The high-rise drill consisted of the firefighter carrying either a hose or an appliance kit up four flights of stairs to the top of the smoke-filled tower, reaching the pipe where the hose would be attached, and then descending the stairs to the bottom of the tower. At the search and rescue drill, firefighters crawled on their hands and knees through a smoke-filled two-story residence while following a hose, crawling through props, and making their way up and down stairs to simulate a search and rescue. The fourth drill consisted of practicing car extrication skills outdoors in the sun. The firefighters were allowed to self-pace their completion of the drills. If any of the tasks were completed before the 15 minutes, the firefighters repeated the task for the remainder of the time.

Firefighters were randomly assigned to either the control group (CON) (n=14) or the head cooling group (HC) (n=12) when they arrived at the training facility. The researchers recorded baseline T_{GI} to ensure the ingestible thermistor was functional. Firefighters provided a urine sample and then were weighed; researchers recorded pre-training USG and body mass. With the help of the researchers, firefighters adorned a HR monitor. The researchers ensured the HR strap was functional and recorded the firefighter's HR. Firefighters adorned their steel-toe boots, bunker pants with suspenders,

and bunker coats. The researchers administered the Stroop Color-Word Test to the firefighters³⁵. The researchers also recorded each firefighter's baseline RPE and PTS.

Following this, the firefighters adorned their remaining gear including Nomex hoods, gloves, helmets, Dregar SCBA with mask and a 20-minute 450 psi air bottle (23.3 ± 1.4 kg). Those assigned to the HC group inserted a head cooling gel pack (GelCool Model GX gel packs; GelCool Systems, Inc., Nashville, TN) just removed from the freezer into the top of their helmet (Figure 1). The gel pack was circular with various compartments of gel intended to conform to the shape of the head and helmet. One side was microfiber, which was placed against the participant's head per manufacturer instructions. Some firefighters adjusted the straps inside the helmet to accommodate the size of the gel pack, while others placed it directly behind the straps in the dead space of the helmet. Many of the firefighters mentioned that the gel pack made their helmets feel heavier and/or sit higher on their head, decreasing their personal comfort.

The firefighters reported to the station they picked out of a box at random and completed that drill for 15 minutes, during which HR and T_{GI} were recorded every three minutes for a total of six times per drill. Then, the firefighters reported to the "exchange" area where the researchers recorded only the firefighter's RPE, PTS, and conflicting color Stroop test score (section 3). Following data collection, the firefighters exchanged their air tanks for a new, full tank. Firefighters assigned to the HC group also replaced their head cooling gel pack with a fresh one from the freezer. Following the exchange ($8:31 \pm 1:30$), the firefighters completed the next drill in the sequence of drills for 15 minutes. Then they reported to the rehabilitation (rehab) area where firefighters rested for 15 minutes by sitting in the shade, removing their SCBA, helmet, hood, gloves, and

jacket and lowering their trousers. Firefighters drank water ad libitum. At the beginning and end of rehab, the researchers recorded the firefighter's RPE, PTS, and conflicting color Stroop test score. After rehab, the firefighters redressed and completed the drill-exchange-drill-rehab sequence a second time (Figure 2).

Statistical Analysis

Descriptive statistics were calculated for each variable. Independent samples t tests compared groups by demographics and hydration status. A repeated measures one-way analysis of variance (ANOVA) analyzed group (HC vs. CON) by time (baseline [BSLN], end drill one [D1], end drill two [D2], end rehab one [R1], end drill three [D3], end drill four [D4], end rehab two [R2]) for T_{GI} , HR, SIS, RPE, and PTS. When sphericity was not assumed, a Huynh-Feldt adjustment was used. If interactions were deemed significant by the ANOVA, paired t-tests were used for post-hoc analyses. A correlation analyzed the relationship between T_{GI} and PTS. Significance was set a priori at $p < 0.05$.

Results

Participant and Environmental Characteristics

There were no demographic differences between the HC and the CON groups ($p > 0.05$ [Table 1]). The wet bulb globe temperatures were $27.7 \pm 1.7^\circ\text{C}$ on average. Environmental conditions were hot with an average ambient temperature of $33.1 \pm 1.4^\circ\text{C}$ and a relative humidity of $27 \pm 3\%$. Two training sessions were held each day for three days. The second session on day one was significantly cooler than the second session on day three ($F_{5,13} = 3.748$, $p < 0.05$, $ES = .618$). There were no significant differences between

all other sessions. Average and maximum wet bulb globe temperatures for each day are found in Table 2.

Training Protocol Time

The entire training protocol took $1:57:47 \pm 0:3:21$. Exchanges between drills lasted $8:40 \pm 1:35$. The time to redress after the first rehab and begin the third drill was $7:15 \pm 1:33$.

Gastrointestinal Temperature

Firefighters arrived at the training facility with T_{GI} of $37.70 \pm .3^{\circ}\text{C}$, ranging from 37.19°C to 38.35°C . There was a significant interaction between group and time for gastrointestinal temperature ($F_{1,6} = 2.493$, $p < 0.05$, $ES = .128$). There was a significant main effect for time ($F_{1,6} = 39.029$, $p < 0.05$, $ES = .697$) and no main effect for group ($F_{1,6} = 0.510$, $p > 0.05$, $1-\beta = 0.104$). There was a significant increase in T_{GI} between baseline and all drills and rehabs ($p < .05$) (Figure 3). During the training protocol, firefighters experienced an overall rise in T_{GI} of $1.75 \pm .40^{\circ}\text{C}$, ranging from 1.05°C to 2.49°C . Maximum T_{GI} ranged from 38.93°C to 40.27°C . Gastrointestinal temperatures rose during drills and declined during rehab. Although T_{GI} declined during rehab, it never returned to baseline in the 15-minute rehab. Gastrointestinal temperature remained $0.93 \pm 0.69^{\circ}\text{C}$ higher than baseline at the end of R1 and $0.82 \pm 0.46^{\circ}\text{C}$ higher after R2.

Heart Rate

There was no significant interaction between group and time for HR ($F_{1,6} = 0.596$, $p > 0.05$, $1-\beta = 0.228$). However, there was a main effect of time ($F_{1,6} = 44.559$, $p < 0.05$, $ES = .736$). At the end of each drill, firefighters had a significantly higher HR compared to

baseline and rehabs (Figure 4). There was no main effect for group ($F_{1,6}=.165$, $p>0.05$, $1-\beta=.067$).

Each firefighter's age-adjusted maximal heart rate (MHR) was calculated by subtracting his age from 220. The firefighters' MHR were 180 ± 8 beats per minute (bpm). Maximal HR reached 186 ± 7 bpm with a range of 172 to 198 bpm. Each firefighter reached his MHR at some point during the training protocol. Fifty percent of firefighters worked at a HR greater than their MHR $16\pm 23\%$ of the time spent working during the protocol. All firefighters worked at more than 90% of their MHR $50\pm 30\%$ of the time.

Physiological Strain Index

Physiological strain index score was calculated for each firefighter at the end of each drill and rehab (Figure 5). There was no interaction between group and time for PSI score ($F_{1,5}= 1.691$, $p>0.05$, $1-\beta=.533$) There was a main effect for time ($F_{1,5}=26.699$, $p<0.05$, $ES=.708$) but not group ($F_{1,5}=.105$, $p>0.05$, $1-\beta=.060$). On average, PSI score increased over consecutive drills and then decreased during rehabs. After D1 and D2, PSI rose from 6.2 ± 1.4 to 8.0 ± 1.2 , then PSI decreased to 4.6 ± 2.2 after R1. Following D3 and D4, PSI increased from 6.0 ± 1.6 to 7.3 ± 1.2 . During R2, PSI fell to 3.7 ± 1.6 . Both rehabs and D2 and D4 were significantly different from all other time points and each other ($p<0.05$).

Hydration Status

There were no differences between groups for hydration status and fluid needs including percent dehydration ($t_{1,24}= -.110$, $p>.05$), sweat loss ($t_{1,24}=-1.096$, $p>0.05$), sweat rate ($t_{1,24}= -1.096$, $p>0.05$), USG pre-training ($t_{1,24}= -.524$, $p>0.05$) and post-training ($t_{1,24}= -1.629$, $p>0.05$), and fluid consumed ($t_{1,24}=-.831$, $p>0.05$). Firefighters

weighed 91.2 ± 13.8 kg with a USG of $1.015 \pm .006$ (Figure 6) at the beginning of the training protocol. During the protocol, firefighters consumed $1.7 \pm .8$ L of fluid and had a sweat loss of $2.5 \pm .8$ L (Figure 7). At the conclusion of the training protocol, firefighters lost $0.7 \pm .7\%$ of their body weight (Figure 8) and USG increased to $1.020 \pm .007$.

Cognition

Three firefighters were color blind and therefore unable to participate in the Stroop Test. There was no interaction between group and time for Stroop test interference scores ($F_{1,6}=1.286$, $p>0.05$, $1-\beta=.481$). There was a main effect for time ($F_{1,6}=6.681$, $p<.05$, $ES=.308$), but not group ($F_{1,6}=1.193$, $p>.05$, $1-\beta=.176$). Baseline and scores at the end of drill one were significantly different from all others (Figure 9). Firefighters scored 29 ± 10 on the baseline interference score. During the training protocol, scores generally decreased, indicating improved cognitive flexibility with an increased number of colors stated. As the training protocol progressed, those in the HC group had higher interference scores than those in the CON group, indicating more interference and fewer colors stated. However, this difference was not statistically significant ($p>0.05$).

Perceptual Measures

There was no interaction between group and time for RPE ($F_{1,6}=.089$, $p>0.05$, $1-\beta=.064$). There was a main effect for time ($F_{1,6}=48.556$, $p<.05$, $ES=.719$); there was no main effect for group ($F_{1,6}=.313$, $p>0.05$, $1-\beta=.083$). At the conclusion of each 15-minute drill, both groups felt they were working somewhat hard to very hard. They also perceived they were working harder after D2 and D4 compared to D1 and D3, respectively (Figure 10). Near the end of the training protocol, the CON group perceived to be working harder than the HC group but this difference was not significant ($p>0.05$).

There was no interaction between groups over time for PTS after each drill and rehab ($F_{1,6}=1.436$, $p>0.05$, $1-\beta=.531$). There was a main effect of time ($F_{1,6}=37.733$, $p<0.05$, $ES=.729$) but not group ($F_{1,6}=2.051$, $p>0.05$, $1-\beta=.266$). Throughout the training protocol, the HC group felt cooler than the CON group; however, this difference was not statistically significant ($p>0.05$)(Figure 11).

Perceived thermal sensation and gastrointestinal temperature

Only weak to moderate relationships were present between PTS and T_{GI} measured at the same time point ($r=.248$, $p>0.05$). The relationship between PTS and T_{GI} was only significant at the end of the third drill, but was only moderately correlated ($r=.581$, $p<0.05$).

Discussion

While there have been studies that have examined head cooling devices, this was the first study to investigate head cooling during firefighting. The purpose of the study was to determine the physiological and perceived effects of head cooling on firefighters performing simulated firefighting drills. Head cooling was found to be ineffective in reducing T_{GI} , HR, PSI, RPE, and PTS. Additionally, USG, percent dehydration, sweat loss, and sweat rate were not affected by the head cooling device.

Gastrointestinal Temperature

For all firefighters, T_{GI} increased between consecutive drills (D1 to D2, and D3 to D4) and decreased during rehabs. Firefighter's maximum T_{GI} ranged from 38.9-40.3°C throughout the training protocol, similar to other studies reporting maximum T_{GI} during drill and rehab sequences ranging from 38.4 to 41.1°C.^{5, 7, 8} The head cooling gel pack had no significant effect on T_{GI} in firefighters in the current study, while other means of

cooling, such as torso cooling via ice and phase change material vests and cooling of the hands and forearms via immersion in cold water, have been successful at significantly and practically reducing T_{GI} in firefighters using accessory cooling means compared to those who did not.^{24, 26, 27, 38}

The inadequate performance of the head cooling device may be explained by the head cooling device's limited ability to stay cool and allow the head to effectively transfer heat. Data in the present study are similar to Wickwire et al, who found that forehead skin temperature and the temperature of a cooling pad inside a helmet equalized within 30 minutes.³¹ Increased temperature gradients between two objects allow for improved heat dissipation. However, the quick temperature equalization of the cooling device and the skin reduced the temperature gradient between the gel pack and the skin, diminishing the ability to dissipate heat. Although the gel pack was replaced with a new one from the freezer before each drill (15 minutes) in the present study, it still had no effect on T_{GI} . The ability to effectively transfer heat away from the head may also have been limited by the awkward fit inside the helmet reported by many of the firefighters, yielding a decreased surface area of contact between the gel pack and the head. Since the gel pack sat directly on the superior portion of the head, the amount of hair a firefighter possessed may also have limited contact.

Accessory cooling methods, such as ice vests and hand/forearm immersion, which are successful at reducing T_{GI} , have a greater surface area of contact between the skin and the cooling means compared to the gel pack and the head. Additionally, assuming there is some movement of the hands and forearms during submersion in cold water, it allows

heat transfer via the more efficient means of convection³⁹ as opposed to conduction found in the direct contact between the head and the gel pack in the current study.

Both groups reached their peak temperatures in the first half of the training protocol and exhibited greater T_{GI} in D1 and D2 compared to D3 and D4. This may be evidence of reduced self-pacing on the part of the firefighters to lower physiological stress^{40, 41} and protect themselves from injury or illness,⁴² since the intensity at which the drills were performed was not specified as part of the training protocol. However, there are situations in which firefighters may not be able to self-pace (i.e. an actual fire call or live-fire drill). In these situations, we may see T_{GI} rise to a greater extent than it did in this protocol since the firefighters will not have the option to voluntarily decrease their intensity of work. In this case, the firefighters' lack of effective cooling means while being motivated to work beyond physiological constraints may put firefighters at risk for injury or illness.

Heart Rate

For all firefighters, HR increased during drills and decreased during rehabs. Throughout the protocol, firefighters worked at up to 104 ± 5 percent of their MHR, with HR reaching 183 ± 10 bpm, similar to other drill and rehab sequenced studies.^{2, 3, 5} Head cooling did not significantly reduce HR. The present study demonstrated that head cooling had no effect on T_{GI} and another study reported it to have no influence on plasma volume³¹. Therefore, it is likely the body shunted blood to the periphery in order to allow for a heat transfer to the environment as a means of cooling. This shift in blood flow explains the increase in HR in order to maintain cardiac output. Additionally, with no vasomotor control in the head, the gel pack would not have been able to cause the blood

vessels in the head to constrict to promote an increase central blood volume and reduce cardiovascular strain. High ambient temperatures may have contributed to the cardiovascular drift observed in these firefighters.⁴³ Physical effort and the intensity at which they performed the drills may have also been factors in the increased HR and T_{GI} observed. Slightly higher HR were reached and maintained during D1 and D2 compared to D3 and D4 for both groups. This may be evidence of fatigue and self-pacing on the part of the firefighters in order to protect themselves. As discussed earlier, firefighters are often in situations where they are unable to control the intensity at which their physical work is performed due to a live fire. In this situation, firefighters will be at risk of working beyond physiological limitations without an effective means of reducing HR.

Physiological Strain Index

A study by Kalyani et al. investigated the PSI of firefighters wearing firefighting protective clothing and usual work clothing while performing the Bruce exercise protocol. Physiological strain index scores recorded were 6.15 ± 1.12 .⁴⁴ During the drills performed in the present study, PSI scores were 7 ± 1 among firefighters, indicating moderate to high physiological strain, representing increased HR and T_{GI} .

Reliable data regarding PSI among firefighters are limited in the literature. Physiological strain index scores in the study by Kalyani et al. were calculated using core body temperatures obtained with a tympanic membrane measuring method, which has been found to be unreliable.⁴⁵ Using the ingestible thermistors to measure T_{GI} was found to be a more reliable method of assessing core body temperature when compared to rectal temperature, the gold standard.⁴⁶

In the present study, PSI score of firefighters increased over consecutive drills. Physiological strain index score was lower in D4 compared to D2 on average for all firefighters. Since the firefighters were not required to complete the drill stations at a certain pace, reduced PSI score in D4 compared to D2 may be explained by reduced self-pacing by the firefighters due to fatigue and/or to protect themselves from working beyond their physiological capabilities and the critical T_{GI} .⁴² Head cooling did not have a significant effect on physiological strain, likely due to its inability to reduce T_{GI} and HR as discussed earlier.

The PSI was developed as an index of quantifiable heat stress during occupational exposure resulting from reactions of the thermoregulatory and cardiovascular systems. Those displaying high PSI scores possibly exhibit greater body heat storage and cardiovascular strain to the metabolic and environmental conditions. Additionally, the PSI assumes that heart rates will remain between 60 and 180 and that T_{GI} will remain between 36.5 and 39.5°C in order to meet the 0 to 10 scale criteria. In actual occupational exposure, however, T_{GI} or HR higher than accounted for by the scale is possible. Firefighters with high PSI (score greater than 7) as well as those who display physiological characteristics greater than the index can accommodate, are thus at a greater risk of developing an EHI.

Hydration Status

During the training protocol, 10.5% of firefighters lost a maximum of 1.9% of their body weight; all others lost less fluid or gained weight. These results vary from a report by the Orange County Fire Association (OCFA) stating that 53% of firefighters lost 2-3% of their body weight, and 5% lost more than 3% of their body weight in a

training exercise similar to the first half of the protocol in this study.⁴⁷ Firefighters in the current study may have appeared to lose less of their body weight if the fluid lost collected in the shorts in which they were weighed. In addition, the firefighters had two breaks, 15 minutes for each set of 30 minutes worked, during the training protocol. This may have allowed the firefighters time to recover and replenish fluid lost during the drills. However, losing even 1-2% of your body weight can lead to detriments in both physiological function and performance, while losing more than three percent may also increase one's risk of developing an EHI.³³

Additionally, head cooling had no effect on sweat loss or sweat rate. Sweat rates observed in firefighters were within normal values.^{15, 33} While T_{GI} rose similarly between groups, the need for sweating to promote heat loss via evaporation may also be similar. Sweat rate and sweat loss are typically reduced in more extreme conditions of hypohydration (more than 3% dehydration).⁴⁸ Significant hypohydration was not observed in the firefighters in this study, which may have prevented reductions in sweat rate and sweat loss. It is possible, however, that sweat rates and losses were actually slightly higher than measured since the calculation was based on body weight loss; since the firefighters may have retained sweat in the shorts or pants they wore while being weighed. If so, their post-exercise body weight would be greater than reality, masking dehydration and sweat loss results.

Twenty-six percent of firefighters in the present study arrived dehydrated (USG between 1.020 and 1.030). Following training, 58 percent of firefighters were dehydrated to some degree. A report by the OCFA found similar results pre-training but did not assess USG after training in their study.⁴⁷ In the present study, those who were

dehydrated prior to training did not improve their hydration level with fluid consumed during training and had sweat rates within normal values. Beginning the training protocol in an already dehydrated state may have influenced physiological characteristics, such as T_{GI} and HR.⁴⁹ Although performance deficits are often associated with dehydration greater than 3%, it is possible that performance may be affected at lesser degrees of dehydration.³³ This may have played a role in the degree to which firefighters paced themselves during the training protocol.

Head cooling did not have an effect on hydration status of firefighters. During data collection, firefighters were observed encouraging and reminding each other to drink fluids during the rehab, indicating the practice of good hydration habits. This behavior may explain why loss of fluids was limited, no firefighter was seriously dehydrated, and no differences were found between groups. Knowing the purpose of the study and recording the amount of fluid consumed may also have influenced their behavior.

Cognition

Stroop test interference scores decreased in both groups as the training protocol progressed, indicating improved test performance. The CON group had a greater decrease in score, and thus a larger improvement in test performance, but this difference was not significant. Therefore, head cooling did not have a significant effect on cognitive performance. The improvement in scores may be due to a learning effect since no familiarization session was used and improvements in scores were seen over the first three test performances. The observed competitiveness that developed between firefighters may also contribute to improved test performance. One study showed improved processing speed in the Headminders Cognitive Stability Index (CSI) test in

participants who were 3.27% dehydrated on average.⁵⁰ The improved processing speed found in that study may be similar to the reduced interference score (increased number of conflicting colors stated) of the firefighters in the current study; however, the firefighters in the current study were dehydrated to a lesser degree, demonstrating less than one percent dehydration on average.

Additionally, firefighters' T_{GI} remained within a reasonable range, rarely exceeding 40°C during the training protocol. This may also explain the lack of change in interference scores between groups. Core body temperatures above 40°C have been associated with central nervous system dysfunction, namely as a symptom of exertional heat stroke.^{14, 15} Hyperthermia has been shown to have an effect on cognitive function, namely memory as opposed to processing speed, response speed, and attention, as measured by Headminder CSI test.⁵¹ This finding may support the lack of change in cognitive function as measured by the Stroop test interference score.

Perceptual Measures

Firefighters reported feeling as though they were working hard to very hard (16 ± 3) during drills, and felt as though they were working harder the more they worked. Other studies regarding firefighters' RPE found similar results, ranging from 13 to 16 during similar drills.² In the present study, head cooling did not have an effect on how hard the firefighters felt they were working. The lack of change in the firefighter's perception of exertion may be explained by the fact that head cooling also had no effect on HR, therefore not relieving any cardiovascular strain. While maintaining maximal or near maximal HR and feeling as though they must work harder in order to complete a task, firefighters may not be able to complete tasks as easily or quickly later in a training

session or extended call. When an actual fire is involved, firefighters may also be motivated to work beyond what they can physiologically tolerate, putting them at risk of suffering an injury or illness.

The firefighters' PTS increased over consecutive drills and decreased during rehabs. Head cooling had no effect on PTS. Although the firefighters in the head cooling group may have generally felt cooler, the difference was not statistically nor practically significant. In actuality, the T_{GI} of the HC group was higher than the CON group, but the difference was not statistically significant. The inability of the head cooling device to change the user's PTS may be due to a poor and uncomfortable fit within the helmet noted by the firefighters, as well as the barrier of their hair between the gel pack and their skin. This decreased surface area of contact between the gel pack to skin may have inhibited the device from having an effect on the firefighters' perceptions. The firefighters also stated that any cooling sensation they felt diminished very quickly once they started working, similar to Wickwire et al.'s findings.³¹

Gastrointestinal Temperature and Perceived Thermal Sensation

No relationship was found between the firefighters' PTS and T_{GI} . Perceived thermal sensation may be influenced more so by skin temperature as compared to T_{GI} . Wickwire et al. found that those using a head cooling device perceived themselves to be cooler than those in the control group without any significant difference in T_{GI} between groups.³¹ That study also found that forehead skin temperature of those in the head cooling group remained lower than those in the control group for approximately 50 minutes.³¹ This may indicate that PTS is determined, to a greater extent, by perception of skin temperature as opposed to T_{GI} . The difference in sensation versus actual temperature

can be dangerous for firefighters, either in training or fighting a live fire. Firefighters will be motivated to perform their job to the best of their ability, and the lack of correlation between thermal sensation and gastrointestinal temperature can put them at risk of re-entering a fire when their CBT is dangerously high. During training sessions and extended fire calls, particular attention should be given to recognize the outward signs of fatigue and EHI in firefighters on the job. Recognizing early signs of an EHI can prevent a firefighter who is unfit to continue working from re-entering the fire and working beyond his or her physiological capability. In extended drills or fires, emergency services personnel should be on site to measure each firefighter's CBT with an effective means before allowing them to continue working if an EHI is suspected.

Conclusion

This study has demonstrated that among career firefighters performing simulated firefighting activity, head cooling did not affect physiological function, including T_{GI} , HR, physiological strain, cognition, or hydration status. Additionally, it did not affect how hard a firefighter felt he was working or the firefighters' thermal perception. No relationship was found between thermal sensation and T_{GI} ; therefore, a firefighter should not rely solely on how hot or cold they feel in determining whether they should continue working. Ultimately, head cooling via a frozen gel pack provided no physiological or perceptual benefit to career firefighters while performing firefighting drills, and therefore, it should not be used.

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Table 1. Demographics by group (mean $\pm$ SD).

	HC	CON
Age (years)	40 $\pm$ 6	41 $\pm$ 9
Height (cm)	170 $\pm$ 7	166 $\pm$ 8
Weight (kg)	97 $\pm$ 17	89 $\pm$ 12
Estimated oxygen consumption (ml/kg/min)	52.2 $\pm$ 7.6	50.2 $\pm$ 7.3

Table 2. Average and maximum WBGT outdoors over days and inside the training facility.

	DAY ONE	DAY TWO	DAY THREE	TOWER
Mean $\pm$ SD	26.2 $\pm$.5	27.5 $\pm$ 1.6	28.9 $\pm$ 1.5	30.7 $\pm$ 2.1
Max WBGT	27.1	29.6	32.6	32.1

Note: Day one was significantly cooler than day three.

Figure 1. Head cooling gel pack and firefighting helmet.

Gel pack fitted inside of firefighting helmet.

Figure 2. Training protocol order of events.

Note: *RPE, PTS, Stroop test recorded; - HR and T_{GI} recorded; drill: firefighters completed firefighting drills; xch: firefighters exchanged air cylinders and measurements were recorded; rehab: firefighters rested in the shade.

Figure 3. Gastrointestinal temperatures by group at the end of each station.

Note: HC= head cooling group; CON= control group

a = BSLN < all

b = D2 > all

c = D4 > BSLN, D1, D3, R2

Figure 4. Heart rate by group at the end of each drill and rehab.

Note: HC= head cooling group; CON= control group

a = D1, D2, D3, D4 > BSLN, R1, R2

b = R2 < BSLN, R1

Figure 5. Average Physiological Strain Index score at the end of each drill and rehab.

Note: HC= head cooling group; CON= control group

a = D2 > all

b = R1 < D1, D2, D3, D4

c = D4 > D1, R1, D3, R2

d = R2 < all

Figure 6. Urine specific gravity before and after training by group.

Note: PRE= USG before training protocol; POST= USG after training protocol; HC= head cooling group; CON=control group

•No differences between groups for USG pre-training ($t_{1,24} = -.524$, $p > 0.05$) and post-training ($t_{1,24} = -1.629$, $p > 0.05$)

Figure 7. Sweat loss, sweat rate, and fluid consumed during training protocol.

Note: CON= control group; HC= head cooling group

- No differences between groups for total sweat loss ($t_{1,24}=-1.096$, $p>0.05$), sweat rate ($t_{1,24}=-1.096$, $p>0.05$)
- No difference between groups for fluid consumed ($t_{1,24}=-.831$, $p>0.05$)

Figure 8. Percent dehydration after training protocol.

Note: CON= control group; HC= head cooling group

•No differences between groups for percent dehydration ($t_{1,24} = -0.110$, $p > .05$)

Figure 9. Stroop test interference scores throughout training protocol.

Note: HC= head cooling group; CON= control group

A higher score indicates decreased performance, i.e. less correct colors stated; a lower score indicates increased performance, i.e. more correct colors stated.

a = BSLN, D1 > D2, R1, D3, D4, R2

Figure 10. Rating of perceived exertion during training protocol.

Note: HC= head cooling group; CON= control group

a = BSLN < all other time points

b = D1 < D2, D4; D1 > BSLN, R1, R2

c = D2, D4 > BSLN, D1, R1, D3, R2

d = R1, R2 < D1, D2, D3, D4

e = D3 > BSLN, W2, R1, R2; D3 < D2, D4

Figure 11. Perceived thermal sensation during training protocol.

Note: HC= head cooling group; CON= control group

a = BSLN, R1 < D1, D2, D3, D4, R2

b = D1, D3 > BSLN, R1, R2; D1, D3 < D2, D4

c = D2, D4 > BSLN, D1, R1, D3, R2

d = R2 < all

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APPENDIX A: STUDY PARAMETERS

Operational definitions

Physiological effects: changes in variables including gastrointestinal temperature, heart rate, Stroop Test interference score, and hydration measures (percent dehydration, urine specific gravity, sweat loss, sweat rate, fluid consumed)

Perceived effects: changes in variables including perceived thermal strain and rating of perceived exertion

Head cooling: a means of accessory cooling; in this study, a frozen gel pack placed inside in the upper portion of a firefighting helmet worn during firefighting activity

Simulated firefighting activity: typical drills performed by firefighters during training that mimic actual events that would happen during an actual firefighting call. These drills included a search and rescue obstacle course, a high-rise drill, a two-story smoked search and rescue drill, and car extrication.

Career firefighter: a firefighter who is employed full-time by a fire department

Good health: a firefighter who does not take medication for cardiovascular disease and has no work related restrictions requiring any type of accommodation.

Training protocol: the work/rest cycle of drills and recovery completed by participants.

Assumptions

- The fire department regulated the personal protective equipment and undergarments worn by the firefighters, so we assume there was no difference between participants in clothing and gear.
- We assume the firefighters' physical ability is similar with respect to simulated firefighting drills since all firefighters are required to be able to complete the same work related tasks.
- The firefighters were assigned to groups randomly, so we assume it was unnecessary to match groups by physical characteristics.

Delimitations

- The applicability of the results of this study was limited to career firefighters, specifically those who work under the guidelines imposed by the Terre Haute Fire Department, Terre Haute, Indiana.
- The applicability of the results of this study was limited to simulated firefighting tasks, such as training drills and car extrication, rather than a live-fire scenario. In addition, it was limited to a training setting where firefighters typically allow themselves to self-pace.
- The applicability of the results of this study was limited to the effects of the GelCool gel pack (model GX) manufactured by GelCool Systems, Inc. of Nashville, Tennessee.

Limitations

- As researchers, we were unable to control the weather and environmental conditions in which the firefighters performed the training protocol.

- Due to the nature of their profession and the fact that the firefighters were taken out of service while on the job to complete the training protocol, we were unable to control for activity completed prior to participation in the study.
- Not all firefighters who participated in the study were able to complete the training protocol in the same day. Given this limitation and the fact that firefighters naturally communicate between shifts, those who completed the training protocol on the first day communicated to those testing the second day and so on regarding specifics of the training protocol and how to better prepare for it with simple behavior modifications, such as improving hydration.
- Since the design of the firefighting drills was referred to the expertise of the fire department training chief, we could not control the types of drills performed nor the personal motivation or intensity at which the firefighters completed the activities.
- Firefighters were weighed wearing the shorts or pants they wore under their protective equipment before and after the training protocol. After the training protocol, sweat had collected in the firefighters' shorts and pants, thus affecting their post-training weight, and potentially their percent dehydration, sweat loss, and sweat rate calculations.

APPENDIX B: PILOT RESEARCH

Methods

Members of the department could not complete the exact protocol in order to truly pilot the methods due to our lack of training in firefighting skills. In place of a true pilot, we completed many walk-throughs to adjust the logistics of the methods, culminating in a dry run of the training protocol with the research assistants practicing their role in data collection by following a “subject” through their assigned drill to familiarize themselves with protocol and the equipment. The training protocol script was tested and modified during this walk-through.

Data by Subject and Results

No data was analyzed since it was not a true pilot regarding the effects of the independent variables.

APPENDIX C: RELEVANT STUDY FORMS

Data collection forms

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

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

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

Is your annual medical physical on file with the fire department?

YES / NO

I certify that all the information provided is correct.

Participant Signature

Date

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

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

Did you work yesterday? YES / NO

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

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

Day One – date _____
Participant # _____

Informed Consent Form

Completed? Yes / No

Health History Questionnaire

Completed? Yes / No

Current Health Questionnaire

Completed? Yes / No

Demographics

Age _____

Step Test Results

HR 15 seconds after completion of 3 minute step test _____bpm

HR 60 seconds after completion of 3 minute step test _____bpm

Day One – date _____
Participant # _____

Informed Consent Form

Completed? Yes / No

Health History Questionnaire

Completed? Yes / No

Current Health Questionnaire

Completed? Yes / No

Demographics

Age _____

Step Test Results

HR 15 seconds after completion of 3 minute step test _____bpm

HR 60 seconds after completion of 3 minute step test _____bpm

Pre / Post Data**Date** _____ **Firefighter #** _____

Age	
Height	
BW _{initial} (kg)	
USG _{initial}	
BW _{gear} (kg)	
HR	
GI _{temp} (°C)	
RPE _{pre}	
PTS _{pre}	
Stroop _{pre}	/ /
BW _{final} (kg)	
Fluid consumed	
USG _{final}	

Pre / Post Data**Date** _____ **Firefighter #** _____

Age	
Height	
BW _{initial} (kg)	
USG _{initial}	
BW _{gear} (kg)	
HR	
GI _{temp} (°C)	
RPE _{pre}	
PTS _{pre}	
Stroop _{pre}	/ /
BW _{final} (kg)	
Fluid consumed	
USG _{final}	

Quick Sheet – Field Data Collection

Date _____

Subject #	Firefighter #	Firefighter #	Firefighter #	Firefighter #	Firefighter #
Watch time	Watch time	Watch time	Watch time	Watch time	Watch time
Protocol time	Protocol time	Protocol time	Protocol time	Protocol time	Protocol time
HR	HR	HR	HR	HR	HR
Gltemp	Gltemp	Gltemp	Gltemp	Gltemp	Gltemp
RPE	RPE	RPE	RPE	RPE	RPE
PTS	PTS	PTS	PTS	PTS	PTS
Stroop	Stroop	Stroop	Stroop	Stroop	Stroop

Firefighter #	Firefighter #	Firefighter #	Firefighter #	Firefighter #	Firefighter #
Watch time	Watch time	Watch time	Watch time	Watch time	Watch time
Protocol time	Protocol time	Protocol time	Protocol time	Protocol time	Protocol time
HR	HR	HR	HR	HR	HR
Gltemp	Gltemp	Gltemp	Gltemp	Gltemp	Gltemp
RPE	RPE	RPE	RPE	RPE	RPE
PTS	PTS	PTS	PTS	PTS	PTS
Stroop	Stroop	Stroop	Stroop	Stroop	Stroop

Firefighter #	Firefighter #	Firefighter #	Firefighter #	Firefighter #	Firefighter #
Watch time	Watch time	Watch time	Watch time	Watch time	Watch time
Protocol time	Protocol time	Protocol time	Protocol time	Protocol time	Protocol time
HR	HR	HR	HR	HR	HR
Gltemp	Gltemp	Gltemp	Gltemp	Gltemp	Gltemp
RPE	RPE	RPE	RPE	RPE	RPE
PTS	PTS	PTS	PTS	PTS	PTS
Stroop	Stroop	Stroop	Stroop	Stroop	Stroop

Data collector:

Training Protocol Script

- Arrive at training facility at time TBA
- Help set up rehab/reporting area >>> everyone
 - freezer
 - Rehab chairs (3)
 - Head cooling gel packs
 - 2-10 gals for water
 - water bottles (labeled with subject number)
 - measuring cup
 - probes/reader
 - 2- injury ice chests, bags, wrap
 - 2 - 10gals ice
 - AT kit
 - labels
 - markers
 - white tape
 - Urine cups (labeled)
 - Paper towels
 - Scale
 - Refractometer
 - Pipettes
 - Kimwipes
 - Distilled water
 - Squirt bottle
 - Rinse container
 - Pre post data sheets
 - Quick sheets
 - Stop watches
 - Pens
 - Clip boards
 - Data recorders
 - Polar watches
 - RPE/PTS sheet
 - Stroop Test
 - Bleach
 - Duct tape
 - Blank paper
 - Signs for exchange; rehab; drills

- Set up rehab/reporting area >>> everyone
 - Set up drills/protocol signs >>> everyone
 - Signs with A, B, C, D
 - Duct tape
 - Sign for exchange
 - Sign for rehab
 - Greeter for trucks that arrive >>> Janie, Tiffani
 - FF arrive - Escort to reporting/rehab tent >>> Janie, Tiffani
 - FF pull group out of hat >>> Amy or Susan
 - FF pull starting drill station out of hat >>> Amy or Susan
 - Label with FF# >>> Amy or Susan
 - blue=arm chair
 - green=head
 - red=control
 - FF assigned to researchers based on drill station starting point>>> Amy or Susan
 - Group at drill A = Meg
 - Group at drill B = Dave
 - Group at drill C = Andy
 - Group at drill D = Meghan
 - 5th receiver = Susan or Amy
 - official time = Amy
 - Record baseline HR/temp on pre/post sheet >>> receivers
 - Orientation for FF, special instructions >>> Amy or Susan
-
- 1. FF provide **urine** sample in labeled cup, return to rehab tent >>> Dana, Tiffani
 - FF get **height** measured in cm on pre/post sheet >>> Jennifer, Janie
 - 2. FF get **initial body weight** in kg (shorts only- tshirt if they are strongly opposed) on pre/post sheet >>> Jennifer, Janie
 - FF **adorn heart rate strap** >>> Dr. Kingsley, Yoder, Andy, Meghan, Dave
 - FF **adorn gear**
 - FF get **gear body weight** on pre/post sheet >>> Jennifer, Janie
-
- Baseline RPE, PTS, Stroop** on pre/post sheet >>> Amy, Jennifer, Janie, Dana, Tiffani, Yoder, DK, Susan
- HR, temp** on quick sheet >>> receivers
-
- DRILLone (15 mins)**•Send to drill one >>> Amy
- Check time on your watch! >>> everyone
- Collect **HR/temp every 3-5 mins** (protocol time: 1-letter of drill station) >>> receivers
- 2 minute warning, FF begin to exit >>> Amy
- Encourage FF to keep moving if they exit before 15 mins >>> everyone
-
- EXCH**•Announce FF to exchange tent >>> Amy
- Collect **HR, temp at beginning** of exchange (final data point drill 1) >>> receivers
- Collect **PTS, RPE, Stroop** (protocol time: 1) >>> Amy, Janie, Tiffani, Yoder, DK, Susan
- Instruct FF to **exchange** (cylinders, head cooling) if applicable

•**DRILLtwo (15 mins)**•Send to drill two >>> Amy

Check time on your watch!

Collect **HR/temp every 3-5 mins** (protocol time: 2-letter of drill station) >>> receivers

2 minute warning, FF begin to exit >>> Amy

Encourage FF to keep moving if they exit before 15 mins >>> everyone

•**REHABone (15 mins)**•Announce FF back to rehab tent for rehab >>> Amy

Collect **RPE, PTS, Stroop** (protocol time: 2)>>> Amy, Janie, Tiffani, Yoder, DK, Susan

Collect **HR, temp** every 3 mins (protocol time: R1) >>> receivers

2 minute warning >>> Amy

Collect **RPE, PTS, Stroop** (protocol time: 3)>>> Amy, Janie, Tiffani, Yoder, DK, Susan

Collect **HR,temp** (protocol time: R1) >>> receivers

Announce end of rehab >>> Amy

FF get dressed

•**DRILLthree (15 mins)**•Send to drill three >>> Amy

Check time on your watch!

Collect **HR/temp every 3-5 mins** (protocol time: 3-letter of drill station)>>> receivers

2 min warning, FF begin to exit >>> Amy

Encourage to keep moving >>> everyone

•**EXCH**•Announce FF back to rehab tent to exchange (cylinders, head cooling) >>> Amy

Collect **HR, temp** at beginning of exchange (last data point of drill 3)>>> receivers

Collect **PTS, RPE, Stroop** (protocol time: 4)>>> Amy, Janie, Tiffani, Yoder, DK, Susan

Instruct FF to **exchange** (cylinders, head cooling) if applicable

•**DRILLfour (15 mins)**•Send to drill four >>> Amy

Check time on your watch!

Collect **HR/temp every 3-5 mins** (protocol time: 4-letter of drill station)>>> receivers

2 minute warning, FF begin to exit >>> Amy

Encourage FF to keep moving if they exit before 15 mins >>> everyone

•**REHABtwo (15 mins)**•Announce FF back to rehab tent for rehab >>> Amy

Collect **RPE, PTS, Stroop** (protocol time: 5)>>> Amy, Janie, Tiffani, Yoder, DK, Susan

Collect **HR, temp every 3 mins** (protocol time: R2) >>> receivers

•**END**•Announce end of rehab >>> Amy

Collect final **PTS, RPE, Stroop** (protocol time: 6)>>> Amy, Janie, Tiffani, Yoder, DK, Susan

Collect final **HR, temp** (protocol time: R2)>>> receivers

Instruct FF to **remove gear**

1. Collect **BW final** >>> Janie

2. Collect **urine sample** >>> Tiffani

Collect **fluid consumed** >>> Amy, any available RAs

Thank FF for participating >>> Amy/Susan

Stroop Test – Section 1

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Stroop Test – Section 2

Stroop Test – Section Three

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Rating of Perceived Exertion

Rating of Perceived Exertion

6

7 Very, Very Light

8

9 Very Light

10

11 Fairly Light

12

13 Somewhat Hard

14

15 Hard

16

17 Very Hard

18

19 Very, Very Hard

20

Perceived Thermal Sensation

Thermal Scale

- 0 Unbearably Cold
- 1 Very Cold
- 2 Cold
- 3 Cool
- 4 Comfortable
- 5 Warm
- 6 Hot
- 7 Very Hot
- 8 Unbearably Hot

Institutional Review Board Informed Consent Form

CONSENT TO PARTICIPATE IN RESEARCH

Physiological and perceived effects of field cooling during simulated firefighting activity

You are asked to participate in a research study during a normal department training session conducted by Dr. Susan Yeargin, Amy McKenzie, Dr. Lindsey Eberman, and Dr. Derek Kingsley, from the Department of Applied Medicine and Rehabilitation at Indiana State University. A portion of this study will be used for Amy McKenzie to complete her Master's Thesis. Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand, before deciding whether or not to participate.

You have been asked to participate in this study because you are a firefighter and the devices being tested in this study are marketed specifically for you and your occupation. To be eligible in this study, you must be a male/female firefighter between the ages of 18 and 60 and have successfully completed and filed your annual physical examination with the fire department. You should not participate if you cannot perform all job activities without restrictions or accommodations. You should also not participate if you have any form of cardiovascular disease, are taking any medication that alters heart rate, or have a condition that would prevent you from taking the temperature capsule.

PURPOSE OF THE STUDY

The purpose of this study is to determine how your body responds, physically and mentally, to two cooling devices during firefighter department training session. This study will determine if the cooling devices are beneficial to firefighters by reducing the rise in body temperature.

PROCEDURES

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

- Volunteer approximately 4 to 5 hours of your time over two separate days:

Day One:

- Complete a health history questionnaire, informed consent form, and a current health questionnaire.
- Complete a step test. This requires you to step up for three minutes at a fast pace and have your heart rate recorded by wearing a heart rate strap for 15 seconds after completing the test.
- This will require about one hour of your time.

Day Two:

- You will swallow a capsule at your station in order to measure internal body temperature 5-8 hours before arriving at the facility and complete a current health questionnaire asking how you currently feel.
- You will arrive to the District 7 Training Facility for a training session.
- You will stand on a scale wearing only shorts and a sports bra(if female) in order to measure your body weight before and after the training session.
- You will provide a urine sample before and after the training session in order to measure hydration status.
- We will help you secure a strap around your chest to measure heart rate during the training session.
- You will be asked to provide your opinion about how hard or easy you feel you are working and how hot or cold you feel at different times throughout the training session.
- You will be asked to take a verbal test which asks you to say out loud the word or the color in which a word is written at different times throughout the training session to measure brain function.

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- You will complete a departmental training session designed by the training officer while wearing all the appropriate gear, including a self-contained breathing apparatus.. You will do this for 15-minutes, then “exchange” air cylinders and do it again. Then you will “rest” for 15 minutes. and the training session will take approximately one hour and 40 minutes.
- You will be allowed to drink fluids any time you want during the training session.

- You will be randomly placed in one of three groups by pulling a piece of paper out of a hat:
 1. Head cooling group- you will wear a cold gel pack inside your helmet during “work”
 2. Arm chair group- you will “rest” while sitting in a chair with your hands and forearms in cold water
 3. Control group- you will do “work” and “rest” without using a cooling method

POTENTIAL RISKS AND DISCOMFORTS

There are no known discomforts to use of the temperature capsule as it moves through your body. The materials used to make the capsule will not harm you. The known symptoms of capsule rupture are nausea, vomiting, or diarrhea. In 22 years of conducting research using this capsule, there have been no known adverse effects associated with its use. The risk of not passing the capsule is possible, but has never occurred. Passage of the capsule is similar to passing a small marble. You are encouraged to immediately report to any of the researchers if any of the above mentioned symptoms arise.

You may also be at risk of developing a heat illness during this study (heat cramps, heat exhaustion, and heat stroke). However, this risk is no greater than during any other training session. Additionally, your body temperature will be monitored throughout the study. You will have the opportunity to stop participating in the training sessions at any time for any reason. Also, if you experience symptoms of a heat illness (nausea, dizziness, muscle spasms, confusion, disorientation, or personality changes), your training officer will be made aware of the situation and you will be asked to stop exercising. Should you require treatment, at least one certified professional will be present to provide you the appropriate treatment, which typically involves drinking water, resting, and cooling the body with cold water tubs. You are responsible for any cost associated with further evaluation and treatment of any injury you sustain while participating in this study.

There are no known risks with using the head cooling device or arm chair cooling device. The only discomfort you may experience is a sensation of cold on your head or arms and possibly shivering.

You may be at risk of embarrassment during this study since you will be asked to step on a scale wearing only shorts and a sports bra, expose your chest to apply a strap to measure heart rate, and provide a urine sample. This risk is minimal, as the researchers will do their best to make these processes as quick as possible. Additionally, you may be allowed to keep your shirt on and you will provide your urine sample in a private bathroom and return it to the researchers wrapped in a paper towel.

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POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

By participating in this study, you will benefit by learning about your hydration status, heart rate, body temperature, and sweat rate. With this information, you can better adjust your training and water drinking habits to enhance your safety while on the job. There are no other direct benefits to you.

Additionally, based on the outcomes of this study, fire departments can make more educated choices on the use of various cooling methods during extended fire emergencies and during training sessions. Choosing good cooling methods will keep firefighters safer and possibly avoid heat illnesses.

INCENTIVE FOR PARTICIPATION

There will be a drawing, for two people to win a free dinner at Stables Restaurant. At the completion of the study, your study number will be placed in a hat and two people will be randomly chosen to win the dinner. If you choose to withdrawal from the study during the training session, you will still be included in the drawing.

CONFIDENTIALITY

Any information that is obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of assigning you a number. This number will be recorded on a master list that will be seen only by the researchers. The master list and all data sheets will be kept in a locked file cabinet by the primary investigator and then stored in a password-protected folder on a computer. It is not possible to hide your participation in the study from peers or administrations that are training at the facility with you since you will be wearing a subject number on your uniform sleeve. However, the Chief and Training Officer are supportive of the study.

PARTICIPATION AND WITHDRAWAL

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

The investigator may withdraw you from this research if circumstances arise which warrant removal. If you display signs or symptoms of a heat illness, you will be asked to discontinue the training for your own safety.

IDENTIFICATION OF INVESTIGATORS

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

Susan Walker Yeargin, PhD, ATC
susan.yeargin@indstate.edu
812-237-3962

Amy L. McKenzie, ATC, PES
amckenzi@indstate.edu
610-551-5487

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RIGHTS OF RESEARCH SUBJECTS

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

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

Printed Name of Subject

Signature of Subject

Date

APPENDIX D: RAW DATA

Subject Demographics and Hydration

SUBJECT	EXPGRP	STARTSTN	AGE	AAMHR	HT (cm)	BWPRE (kg)	BWPOST (kg)	BWGEAR (kg)
1	1	1	47	173	162	90.5	90.7	113.4
5	2	2	46	174	175.2	105.6	104.1	128.5
6	1	4	27	193	176.4	100	99	125.2
7	1	1	54	166	159.6	71.1	70.8	94.6
9	2	1	39	181	164.4	89.3	89.8	114
12	1	4	39	181	164.4	72.7	71.4	96.1
14	2	3	37	183	168	87.8	87.2	111.4
15	1	4	48	172	156	78.2	77.9	100.2
16	2	1	34	186	175.2	102.8	103.1	127.2
17	2	4	54	166	166.8	84.9	83.3	107.2
20	2	2	35	185	159.6	71.3	70.7	95.5
21	1	3	49	171	168	93.3	93.5	116.4
22	1	1	35	185	170.4	98.1	97.6	122.9
23	1	4	40	180	160.8	83	81.9	105.1
24	2	3	43	177	178.8	108.7	108.7	133.3
25	1	1	48	172	169.2	97.5	96.4	122.6
26	2	3	35	185	170.4	80.7	78.8	102.5
28	1	2	40	180	162	104.8	103.2	127
32	1	2	32	188	177.6	92.8	92.1	118.9
33	1	4	41	179	178.8	102.2	101.7	127
34	2	3	37	183	175.2	124.3	124.1	147.7
35	2	2	37	183	175.2	119.3	118.3	144.2
36	2	2	44	176	158.4	76.3	76.1	97.6
37	1	1	26	194	168	92.1	91.5	114.2
40	1	3	54	166	156	66.5	65.9	88.6
41	2	3	44	176	171.6	107.5	105.6	130
min	1control	MIN	26	166	156.0	66.5	65.9	88.6
max	2head	MAX	54	194	178.8	124.3	124.1	147.7
mean		MEAN	41	179	168.0	92.4	91.7	115.8
sd		SD	8	8	7.2	15.0	15.0	15.5

SUBJECT	GEAR WT (kg)	BWL (%)	USGPRE	USGPOST	STEPFIPT	ESTVO15	vo2category	STEPSIXT
1	22.9	-0.2	1.018	1.023	148	49.17	excellent	132
5	22.9	1.5	1.029	1.028	152	47.49	excellent	
6	25.2	1.0	1.011	1.008	135	54.63	good	118
7	23.5	0.3	1.015	1.019	150	48.33	excellent	124
9	24.7	-0.5	1.011	1.019	135	54.63	excellent	110
12	23.4	1.3	1.013	1.022	144	50.85	good	117
14	23.6	0.6	1.021	1.029	151	47.91	good	131
15	22	0.3	1.023	1.024	151	47.91	excellent	120
16	24.4	-0.3	1.01	1.016	126	58.41	excellent	112
17	22.3	1.6	1.015	1.027	117	62.19	excellent	86
20	24.2	0.6	1.019	1.023	126	58.41	excellent	104
21	23.1	-0.2	1.017	1.019				
22	24.8	0.5	1.017	1.023	144	50.85	good	127
23	22.1	1.1	1.016	1.019	129	57.15	excellent	105
24	24.6	0.0	1.019	1.008	170	39.93	above average	142
25	25.1	1.1	1.017	1.023	134	55.05	excellent	96
26	21.8	1.9	1.024	1.028	149	48.75	above average	123
28	22.2	1.6	1.015	1.024	124	59.25	excellent	109
32	26.1	0.7	1.003	1.005	116	62.61	excellent	84
33	24.8	0.5	1.013	1.015	150	48.33	good	132
34	23.4	0.2	1.015	1.019	134	55.05	excellent	105
35	24.9	1.0	1.012	1.027	160	44.13	good	143
36	21.3	0.2	1.009	1.024	122	60.09	excellent	93
37	22.1	0.6	1.022	1.024	187	32.79	poor	165
40	22.1	0.6	1.01	1.003	158	44.97	good	141
41	22.5	1.9	1.01	1.02	167	41.19	above average	144
min	21.3	-0.5	1.003	1.003	116	33		84
max	26.1	1.9	1.029	1.029	187	63		165
mean	23.5	0.7	1.016	1.020	143	51		119
sd	1.3	0.7	0.006	0.007	18	7		20

SUBJECT	ESTVO60	category	RPE	PTS	STROOPA	STROOPB	STROOPC	SIS bsln
1	55.89 exc		9	4	109	78	30	48
5			7	6	94	70	35	35
6	61.77 exc		6	5	94	64	33	31
7	59.25 exc		9	5	122	82	41	41
9	65.13 exc		12	5	108	65	41	24
12	62.19 exc		7	5	91	66	42	24
14	56.31 exc		7	5	70	64	41	23
15	60.93 exc		11	5	97	74	45	29
16	64.29 exc		9	5	98	84	49	35
17	75.21 exc		9	5	81	60	38	22
20	67.65 exc		6	4	93	82	25	57
21			6	4	87	68	37	31
22	57.99 exc		7	2	79	61	22	39
23	67.23 exc		13	5	43	42	40	2
24	51.69 exc		6	4	cb	cb		
25	71.01 exc		7	4	78	43	24	19
26	59.67 exc		7	4	114	67	36	31
28	65.55 exc		6	3	cb	cb		
32	76.05 exc		7	4	cb	cb		
33	55.89 exc		6	4	82	81	42	39
34	67.23 exc		6	5	86	52	25	27
35	51.27 exc		9	5	91	51	41	10
36	72.27 exc		7	5	101	70	46	24
37	42.03 avg		7	6	107	80	49	31
40	52.11 exc		7	4	86	76	33	43
41	50.85 good		6	5	106	92	49	43
								0
min	42		6	2	43	42	22	2
max	76		13	6	122	92	49	57
mean	61		8	5	92	68	38	31
sd	8		2	1	17	13	8	12

SUBJECT	FLDCNSMD (L)	SWL (L)	SWR (L)	PERCDEHY	HRB	GIB	DATE
1	1.55	1.35	0.675	-0.22	100	37.58	16
5	3	4.5	2.25	1.42	95		16
6	1.7	2.7	1.35	1.00	89	37.65	16
7	0.8	1.1	0.55	0.42	87	37.51	16
9	3.45	2.95	1.475	-0.56	84		16
12	1.05	2.35	1.175	1.79	102	37.06	17
14	1.15	1.75	0.875	0.68	106	37.65	17
15	1	1.3	0.65	0.38	87	37.15	18
16	3	2.7	1.35	-0.29	91	38.05	17
17	1.25	2.85	1.425	1.88	77	36.79	17
20	1	1.6	0.8	0.84	84	37.39	17
21	2	1.8	0.9	-0.21	98	37.38	17
22	1.4	1.9	0.95	0.51	95	37.75	17
23	1.75	2.85	1.425	1.33	95	37.23	17
24	2.05	2.05	1.025	0.00	99	37.73	17
25	2.85	3.95	1.975	1.13	66	37.25	17
26	0.5	2.4	1.2	2.35	103		16
28	1.15	2.75	1.375	1.53	87	37.05	17
32	1.5	2.2	1.1	0.75	78	36.77	18
33	2.15	2.65	1.325	0.49	86	37.21	18
34	2.5	2.7	1.35	0.16	81	37.29	18
35	1	2	1	0.84	114	37.53	18
36	1.65	1.85	0.925	0.26	68	37.83	18
37	1.4	2	1	0.65	124	37.55	18
40	1	1.6	0.8	0.90	114	36.86	18
41	0.9	2.8	1.4	1.77	81	37.02	18
min	0.500	1.1	0.55	-0.56	66	36.77	
max	3.450	4.5	2.25	2.35	124	38.05	
mean	1.644	2.33	1.17	0.76	92	37.36	
sd	0.776	0.78	0.39	0.74	14	0.34	

Elapsed Time during Training Protocol

min.sec	16		17		18				
W1-W2	22.35	22.38	24.30	25.41	22.38	21.20			
W2-R1	16.40	16.55	16.15	16.54	16.31	16.00			
R1-W3	24.02	22.30	24.08	20.42	20.50	21.20			
W3-W4	22.56	23.09	26.25	23.58	24.25	22.56			
W4-R2	16.10	16.28	16.38	17.10	16.24	16.58			
R2	15.00	15.00	15.00	15.00	15.00	15.00			
<u>decimal</u>									
W1-W2	22.58	22.63	24.50	26.60	22.63	21.33			
W2-R1	16.67	16.92	16.25	16.90	16.52	16.00			
R1-W3	24.03	22.50	24.13	20.70	20.83	21.33			
W3-W4	22.93	23.15	26.42	23.97	24.42	22.93			
W4-R2	16.17	16.47	16.63	17.17	16.40	16.97			
R2	15.00	15.00	15.00	15.00	15.00	15.00			
TOTAL	117.38	116.67	122.93	120.33	115.80	113.56	decimal overall average time		
	1.90	1.90	2.10	2.70	1.90	1.90	117.78		
AVG	118.00	116.59					3.35		
							real avg time		
							117:47/3:21		
							1:57:47/0:3:21		
<u>all exchange times decimal</u>							<u>average</u>	<u>stdev</u>	
W1-W2	7.58	7.63	9.50	11.60	7.63	6.33	8.38	1.88	W1-W2
W2-R1	1.67	1.92	1.25	1.90	1.52	1.00	1.54	0.37	W2-R1
R1-W3	9.03	7.50	9.13	5.70	5.83	6.33	7.25	1.55	R1-W3
W3-W4	7.93	8.15	11.42	8.97	9.42	7.93	8.97	1.34	W3-W4
W4-R2	1.17	1.47	1.63	2.17	1.40	1.97	1.63	0.37	W4-R2
<u>exchange times decimal</u>							<u>decimal average exchange</u>		
							7.58	7.63	
							9.50	11.60	
							7.63	6.33	
							6.33	8.67	
							7.93	1.59	
							real avg exch time		
							8:40/1:35		
<u>rehab to work times</u>									
							9.02	7.30	
							9.03	7.50	
							9.08	5.42	
							5.50	6.20	decimal avb r to w
							9.13	5.70	6.33
							5.83	7.25	
							1.55		
							real avg time r to w		
							7:15/1:33		

decimal

15
8.38 / 1.88
15
1.54 / .37
15
7.25 / 1.55
15
8.97 / 1.34
15
1.53 / .37
15

time		
15:00/0:00	work one	
8:23/1:53	exch one	
15:00/0:00	work two	
1:32/0:22	work to rest	
15:00/0:00	rest one	
7:15/1:33	rest to work	
15:00/0:00	work three	
8:58/1:20	exch two	
15:00/0:00	work four	
1:32/0:22	work to rest	
15:00/0:00	rest two	

Environmental Conditions

day/session	wbgt	rh	dry	wet	globe	
1A		27.1	25	29.6	21.7	44.2
1A		26.0	26	29.3	21.0	42.0
1A		26.0	25	29.6	21.1	41.0
1B		26.2	25	29.9	21.5	40.4
1B		25.9	30	30.4	21.4	39.9
1B		25.9	25	30.1	21.0	40.7
2A		26.9	28	28.7	21.5	45.1
2A		28.9	26	30.6	22.9	48.0
2A		29.6	25	38.1	25.7	38.3
2B		25.8	25	29.7	21.4	39.5
2B		27.2	27	34.6	24.1	37.9
2B		28.7	28	37.3	25.3	37.0
2B		25.4	32	29.7	21.4	37.3
3A		27.9	28	30.7	22.9	44.3
3A		28.0	30	36.3	24.9	36.3
3A		28.5	34	36.1	25.3	36.1
3A		28.0	29	44.1	22.9	44.1
3B		29.0	27	32.1	23.8	45.4
3B		28.6	27	32.7	23.3	45.1
3B		32.6	24	42.2	28.3	43.0
3B		28.8	26	32.3	23.3	46.0
<hr/>						
day one avg		26.2	26	29.8	21.3	41.4
day one stdev		0.5	2	0.4	0.3	1.6
day two avg		27.5	27	32.7	23.2	40.4
day two stdev		1.6	2	3.9	1.9	4.3
day tre avg		28.9	28	35.8	24.3	42.5
day tre stdev		1.5	3	5.0	1.8	4.0
all avg		27.7	27	33.1	23.1	41.5
all stdev		1.7	3	4.4	2.0	3.6
<hr/>						
day one max		27.1				
day two max		29.6				
day tre max		32.6				
<hr/>						
tower	wbgt	rh	dry	wet	globe	
2A		29.2	25	35.6	25.1	38.4
3B		32.1	25	37.2	27.1	42.8
<hr/>						
avg		30.7	25	36.4	26.1	40.6
stdev		2.1	0	1.1	1.4	3.1

Heart Rate

SUBJ	AAMHR	W1T0	W1T15	W2T15	R1T15	W3T15	W4T15	R2T15
1 c	173	127	152	155	106			
5 h	174	113	157	182	116		174	123
6 c	193	138	178	162	118	156	176	114
7 c	166	110	146	134	97			
9 h	181	99	177	144	96	165	151	92
12 c	181	126	165	196	146	179	185	119
14 h	183	134	177	161	133	169	164	128
15 c	172	100	168	139	121	144	155	98
16 h	186	120	180	153	130	138	161	106
17 h	166	95	144	172	131	147	153	100
20 h	185	110	157	183	108	156	161	94
21 c	171	139	176	179	132	176	164	137
22 c	185	147	176	167	124	168	165	118
23 c	180	105	142	143	112	130	149	88
24 h	177	138	187	188	140	183		
25 c	172	90	150	104	96	133	123	97
26 h	185	95	167	137	100	150	130	
32 c	188	74	134	180	102	130	144	97
33 c	179	98	160	190	137	151	134	123
34 h	183		134	148	111	144	158	70
36 h	176	117	135	165	80	132	151	88
37 c	194	157	187	168	135	177	159	128
40 c	166	152	161	157	162	165	164	149
41 h	176	139	132	186	141	180	174	139

	baseline	drill 1	drill 2	rehab 1	drill 3	drill 4	rehab 2
HC	116	159	165	117	156	158	104
CON	120	161	160	122	155	156	115
HCstddev	17	20	18	20	17	13	22
CONstddev	26	16	25	20	19	18	19

SUBJ	W1T0	W1T3	W1T6	W1T9	W1T12	W1T15	W2T0	W2T3	W2T6
1 c	127	146	144	166	166	152	153	157	156
5 h	113	155	164	168	179	157	161	174	169
6 c	138	181	178	170	170	178	171	188	170
7 c	110	162	170	124	153	146	146	132	143
9 h	99	162	168	172	180	177	160	177	164
12 c	126	163	159	157	162	165	170	187	192
14 h	134	183	177	177	182	177	167	187	
15 c	100	164	178	167	74	168	168	188	149
16 h	120	165	172	178	175	180	167	180	178
17 h	95	147	144	137	125	144	113	160	161
20 h	110	166	160	171	175	157	158	179	184
21 c	139	166	166	165	183	176	168	156	
22 c	147	159	159	172	147	176	152	168	153
23 c	105	135	125	142	140	142	146	159	161
24 h	138	161	175	179	184	187	172	185	
25 c	90	122	129	137	107	150	120	116	103
26 h	95	156	165	171	170	167	157	184	138
32 c	74	80	104	125	162	134	120	145	155
33 c	98	132	165	168	174	160	170	192	191
34 h		154	170	161	163	134	169	148	157
36 h	117	125	125	165	176	135	162	160	160
37 c	157	182	198	179	195	187	179	192	183
40 c	152	158	168	168	169	161	167	182	187
41 h	139	176	168	147	161	132	170	185	188

SUBJ	W3T0	W3T3	W3T6	W3T9	W3T12	W3T15	W4T0	W4T3	W4T6
1 c									
5 h	146		156	164	143			138	176
6 c	157		169	177	174	185	156	167	166
7 c									
9 h	109		148	157	169	174	165	159	169
12 c	173		183	157	180	179	179	175	184
14 h	123		147	162	185	173	169	128	164
15 c	150		159	179	166	180	144	168	157
16 h	135		164	160	171	168	138	154	160
17 h	149		151	146	150	144	147	148	158
20 h	150		156			149	156	158	171
21 c	146		164	171	191	172	176	162	177
22 c	141		140	145	126	162	168	164	174
23 c	123		139	136	138	133	130	135	141
24 h	157		173	175	193	181	183	183	
25 c	114		133	129	139	162	133	121	123
26 h	100		139	168	170	151	150	131	166
32 c	120		130	138	136	138	130	136	169
33 c	152		163	171	152	182	151	146	167
34 h	116		149	160	140	158	144	149	179
36 h	125		138				132	145	146
37 c	154		160	180	178	192	177	194	181
40 c	143		172	171	169	169	165	167	170
41 h	175		185	186	179	192	180	177	164

SUBJ	W4T9	W4T12	W4T15	R2T0	R2T3	R2T6	R2T9	R2T12	R2T15
1 c									
5 h	158	161	174	166	142	130	126	118	123
6 c	166	179	176	158	146	139	117	122	114
7 c									
9 h	159	165	151	145	133	105	102	94	92
12 c	185	185	185	159	153	136	125	121	119
14 h	164	169	164		138	149	137	135	128
15 c	167	168	155	155	118	103	96	93	98
16 h	160	154	161	159	137	134	125	115	106
17 h	157	150	153	154	142	132	121	114	100
20 h	167	165	161	147	116	111	94	98	94
21 c	174	172	164		176	163	158	146	137
22 c	166		165	150	146	151	123	125	118
23 c	146	145	149	148	116	109	97	96	88
24 h					167	148			
25 c	136		123	115	102	106	102	99	97
26 h	135	133	130	154	126	113	97	101	
32 c	150	166	144	132	109	106	100	101	97
33 c	166	170	134	132	117	116	123	133	123
34 h	140	138	158	134	105	97	111	103	70
36 h	156		151		146	117	103	97	88
37 c	160	171	159	167	148	132	147	134	128
40 c	170	171	164	164	154	148	156	148	149
41 h	191	181	174	172		157	146	140	139

SUBJ	max	AAMHR	%maxHR
1 c	166	173	96.0
5 h	182	174	104.6
6 c	188	193	97.4
7 c	170	166	102.4
9 h	180	181	99.4
12 c	196	181	108.3
14 h	187	183	102.2
15 c	188	172	109.3
16 h	180	186	96.8
17 h	172	166	103.6
20 h	184	185	99.5
21 c	191	171	111.7
22 c	176	185	95.1
23 c	164	180	91.1
24 h	193	177	109.0
25 c	162	172	94.2
26 h	184	185	99.5
32 c	182	188	96.8
33 c	192	179	107.3
34 h	179	183	97.8
36 h	176	176	100.0
37 c	198	194	102.1
40 c	187	166	112.7
41 h	192	176	109.1

SUBJ	AAMHR	>90%MHR	>95%MHR	W1T0	W1T3	W1T6	W1T9	W1T12	W1T15	W2T0	W2T3
5 h	174	157	165	113	155	164	168	179	157	161	174
6 c	193	174	183	138	181	178	170	170	178	171	188
9 h	181	163	172	99	162	168	172	180	177	160	177
12 c	181	163	172	126	163	159	157	162	165	170	187
14 h	183	165	174	134	183	177	177	182	177	167	187
15 c	172	155	163	100	164	178	167	74	168	168	188
16 h	186	167	177	120	165	172	178	175	180	167	180
17 h	166	149	158	95	147	144	137	125	144	113	160
21 c	171	154	162	139	166	166	165	183	176	168	156
22 c	185	167	176	147	159	159	172	147	176	152	168
23 c	180	162	171	105	135	125	142	140	142	146	159
25 c	172	155	163	90	122	129	137	107	150	120	116
26 h	185	167	176	95	156	165	171	170	167	157	184
32 c	188	169	179	74	80	104	125	162	134	120	145
34 h	183	165	174		154	170	161	163	134	169	148
37 c	194	175	184	157	182	198	179	195	187	179	192
40 c	166	149	158	152	158	168	168	169	161	167	182
41 h	176	158	167	139	176	168	147	161	132	170	185
average											
st dev											
				119	156	161	161	158	161	157	171
				25	25	22	16	30	18	20	20

SUBJ	AAMHR	%MHR	W3T0	W3T3	W3T6	W3T9	W3T12	W3T15	W4T0	W4T3
5 h	174	67	146	156	164	143			138	166
6 c	193	55	157	169	177	174	185	156	167	177
9 h	181	50	109	148	157	169	174	165	159	161
12 c	181	81	173	183	157	180	179	179	175	190
14 h	183	78	123	147	162	185	173	169	128	150
15 c	172	70	150	159	179	166	180	144	168	144
16 h	186	69	135	164	160	171	168	138	154	148
17 h	166	72	149	151	146	150	144	147	148	159
21 c	171	77	146	164	171	191	172	176	162	172
22 c	185	70	141	140	145	126	162	168	164	171
23 c	180	62	123	139	136	138	133	130	135	150
25 c	172	56	114	133	129	139	162	133	121	130
26 h	185	54	100	139	168	170	151	150	131	132
32 c	188	54	120	130	138	136	138	130	136	171
34 h	183	53	116	149	160	140	158	144	149	
37 c	194	47	154	160	180	178	192	177	194	176
40 c	166	86	143	172	171	169	169	165	167	169
41 h	176	74	175	185	186	179	192	180	177	182
AVERAGE		65	137	155	160	161	167	156	154	162
STDEV		12	21	16	16	20	18	18	20	17

SUBJ	W4T6	W4T9	W4T12	W4T15	R2T0	R2T3	R2T6	R2T9	R2T12	R2T15
5 h	176	158	161	174	166		142	130	126	118
6 c	166	166	179	176	158		146	139	117	122
9 h	169	159	165	151	145		133	105	102	94
12 c	184	185	185	185	159		153	136	125	121
14 h	164	164	169	164	149		138	149	137	135
15 c	157	167	168	155	155		118	103	96	93
16 h	160	160	154	161	159		137	134	125	115
17 h	158	157	150	153	154		142	132	121	114
21 c	177	174	172	164		176	163	158	146	137
22 c	174	166	166	165	150		146	151	123	118
23 c	141	146	145	149	148		116	109	97	88
25 c	123	136		123	115		102	106	102	97
26 h	166	135	133	130	154		126	113	97	101
32 c	169	150	166	144	132		109	106	100	97
34 h	179	140	138	158	134		105	97	111	70
37 c	181	160	171	159	167		148	132	147	128
40 c	170	170	171	164	164	154	148	156	148	149
41 h	164	191	181	174	172	165	157	146	140	139
	165	160	163	158	152	136	128	121	117	112
	15	15	15	16	14	21	21	21	18	21

SUBJ	AAMHR	%MHR	min overall	max overall	%OVER100	%OVER95	%OVER90	max
5 h	174	68	113	182	21	46	67	182
6 c	193	59	107	188	0	8	46	193
9 h	181	51	91	180	0	21	54	181
12 c	181	66	119	196	46	67	79	196
14 h	183	70	118	187	13	29	50	187
15 c	172	54	74	188	21	58	71	188
16 h	186	57	106	180	0	17	42	186
17 h	166	60	95	172	4	21	50	172
21 c	171	80	132	191	50	83	92	191
22 c	185	64	118	176	0	4	38	185
23 c	180	49	88	164	0	0	4	180
25 c	172	56	90	162	0	0	4	172
26 h	185	52	95	184	0	4	25	185
32 c	188	52	74	182	0	8	13	188
34 h	183	38	70	179	0	4	13	183
37 c	194	66	91	198	13	25	71	198
40 c	166	89	142	187	71	88	96	187
41 h	176	79	130	192	58	79	88	192
AVERAGE		62	103	183 average	16	31	50	186
STDEV		13	21	10 st dev	23	31	30	7

SUBJ	first half			2nd half			
	>90	>95	>100		>90	>95	>100
5 h	83	58	25		50	25	17
	42	8	0		50	8	0
6 c							
9 h	67	33	0		42	8	0
12 c	67	0	42		92	92	50
14 h	67	50	17		33	8	8
15 c	67	67	25		75	50	17
16 h	67	33	0		17	0	0
17 h	33	25	8		67	17	0
21 c	92	75	33		92	92	67
22 c	50	8	0		25	0	0
23 c	8	0	0		0	0	0
25 c	8	0	0		0	0	0
26 h	33	8	0		17	0	0
32 c	17	17	0		8	0	0
34 h	17	0	0		8	8	0
37 c	75	33	17		58	17	8
40 c	100	83	67		92	92	75
41 h	75	67	42		100	92	75
	54	31	15	average	46	28	18
	29	29	20	st dev	34	37	28

Gastrointestinal temperature

SUBJ	W1T0	W1T15	W2T15	R1T15	W3T15	W4T15	R2T15	W1T0	W1T3
1 c	37.78	39.02	39.26	38.43				37.78	37.9
5 h	37.72	38.48	39.53	39.52		39.13	39.17	37.72	37.2
6 c	38.35	39.04	39.77	38.83	39.15	39.33	38.76	38.35	38.43
7 c	37.67	38.08	38.87	38.14				37.67	37.7
9 h	37.58	38.34	39.57	38.41	38.35	39.09	38.59	37.58	37.63
12 c		38.14	38.76	38.93		38.53	38.31		37.62
14 h	37.87	38.48	39.03	38.42	38.48	39.19	38.83	37.87	38.06
15 c	37.29	38.22	39.58	39.04	38.57	38.81	38.29	37.29	37.33
16 h	38.22	39.05	40.22	39.50	37.91	38.93	38.47	38.22	38.29
17 h	37.19	37.90	38.78	38.57	38.48	38.73	38.40	37.19	37.3
20 h	37.62	38.71	38.84					37.62	37.65
21 c	37.61	38.05	38.50	37.21	38.74			37.61	37.77
22 c	37.79	38.51	39.57	39.34		38.32	38.28	37.79	37.9
23 c	37.53	37.91	38.87	38.59	38.39	38.60	38.15	37.53	37.53
24 h	38.07	38.65	39.49	39.03	39.00			38.07	38.14
25 c	37.72	38.37	39.26	39.40	38.81	39.28	38.46	37.72	37.56
26 h	37.62	39.04	39.51	37.66	38.27	38.93		37.62	37.71
28 c*	37.25	37.74	38.35	38.01	37.56	37.97	37.68	37.25	37.29
32 c	37.39	38.06	39.44	39.26	38.37	39.44	39.29	37.39	37.43
33 c	37.21	38.01						37.21	37.35
34 h	37.68	38.05	38.92	38.22	38.59	39.07	38.60	37.68	37.8
35 h*	37.84	38.26			38.12	38.84	37.69	37.84	37.84
36 h	37.94	38.50	39.12	37.67	38.19	38.81	38.18	37.94	37.96
37 c	37.79	38.28	38.93	38.74	38.17	38.39	37.83	37.79	37.85
40 c	37.88	37.43	38.35	38.45	38.49	38.74	38.55	37.88	37.2
41 h	37.57	38.08	38.86	38.24	38.93	39.33	38.74	37.57	37.63
		39.07	40.22	39.52	39.15	39.89	39.29	38.35	38.43
		38.37	39.17	38.38	38.37	38.92	38.16	37.69	37.7
min	37.19	37.43	38.35	37.21	37.56	37.97	37.68	baseline	
max	38.35	39.05	40.22	39.52	39.15	39.44	39.29	HC	37.74
avg	37.69	38.32	39.14	38.59	38.45	38.87	38.44	CON	37.64
st dev	0.29	0.42	0.47	0.62	0.38	0.38	0.43	HC stdev	0.27
change		0.64	1.45	0.90	0.76	1.19	0.75	CONstdev	0.31

SUBJ	W1T6	W1T9	W1T12	W1T15	W2T0	W2T3	W2T6	W2T9	W2T12	W2T15
1 c	37.7	38.52	38.65	39.02	38.88	38.93	39.03	39.1	39.17	39.26
5 h	37.84	37.99	38.19	38.48	37.75	38.9	39.05	39.26	39.42	39.53
6 c	38.57	38.75	38.93	39.04		39.37	39.54	39.63	39.72	39.77
7 c	37.74	37.86	37.99	38.08	38.41	38.63	38.71	38.77	38.81	38.87
9 h	37.78	37.92	38.13	38.34	38.71	38.93	39.07	39.23	39.41	39.57
12 c	37.76	37.92	38.02	38.14	38.25	38.2	38.09	38.24	38.55	38.76
14 h	38.13	38.23	38.39	38.48	38.67	38.28		38.86	38.93	39.03
15 c	37.45	37.62	37.85	38.22	38.38	38.61	38.96	39.23	39.43	39.58
16 h	38.38	38.64	38.91	39.05	39.54	39.78	39.89	40.02	40.14	40.22
17 h	37.14	37.64	37.75	37.90	38.05	38.09	38.17	38.42	38.58	38.78
20 h	37.78	37.95	38.13	38.71		38.85	39.25		38.66	38.84
21 c	37.81	37.89	37.99	38.05		38.76		38.42	38.44	38.50
22 c	38.15	38.19	38.33	38.51	38.94	39.13	39.28	39.36	39.45	39.57
23 c	37.58	37.67	37.73	37.91	38.06	38.13	38.37	38.51	38.75	38.87
24 h	38.22	38.33	38.54	38.65	39.08	39.26		39.38	39.5	39.49
25 c	37.64	37.79	38.07	38.37	38.02	38.82	38.95	39.1	39.17	39.26
26 h	37.71	38.14	38.44	39.04	39.12	39.17	39.35	39.51	39.54	39.51
28 c*	37.37	37.45	37.56	37.74	37.96	38.1	38.16	38.28	38.28	38.35
32 c	37.84	37.68	37.91	38.06	38.3	38.45	38.63	38.88	39.35	39.44
33 c	37.47	37.62	37.75	38.01						
34 h	37.86	37.92	37.98	38.05	38.26	38.48	38.49	38.6	38.69	38.92
35 h*	37.9	38.68	38.21	38.26						
36 h	38.05	38.03	38.33	38.50	38.55	38.66	38.76	38.89	39.01	39.12
37 c	37.88	37.91	38.1	38.28	38.76	38.74	38.89	38.94	38.97	38.93
40 c	37.24	37.27	37.36	37.43	37.71	37.89	37.98	38.07	38.1	38.35
41 h	37.8	37.82	38.01	38.08	38.25	38.36	38.53	38.66	38.74	38.86
	38.57	38.75	38.93	39.05	39.54	39.78	39.89	40.02	40.14	40.22
	37.8	38.0	38.1	38.32	38.5	38.7	38.8	38.9	39.0	39.14
drill 1	drill 2	rehab 1	drill 3	drill 4	rehab 2					
38.46	39.26	38.52	38.43	39.01	38.52					
38.20	39.04	38.64	38.47	38.74	38.36					
0.37	0.44	0.66	0.34	0.19	0.42					
0.44	0.48	0.61	0.45	0.48	0.46					

SUBJ	R1T0	R1T3	R1T6	R1T9	R1T12	R1T15	W3T0	W3T3	W3T6	W3T9
1 c	39.26	39.22	39.04	38.92	38.82	38.43				
5 h	39.66	39.86	39.9	39.83	39.71	39.52	39.24	38.84	38.73	38.82
6 c	39.79	39.69		39.42	38.94	38.83	38.45	38.76	38.77	38.92
7 c	38.91	39.01	38.96	38.93	38.21	38.14				
9 h	39.71	39.66	39.43	38.94	38.78	38.41	38.04	37.94	38.03	38.14
12 c	39.05	39.26	39.31	39.26	39.07	38.93	38.61	37.25		
14 h	39.04	38.92	38.61	37.8		38.42	38.11	38.22	38.26	38.32
15 c	39.78	39.73	39.65	39.44	39.25	39.04	38.88	38.56	38.59	38.56
16 h		40.27	40.16	40.02	39.76	39.50	39.16	37.78	37.57	37.24
17 h	38.79	38.96	38.91	38.84	38.71	38.57	37.9	38.2	38.24	38.33
20 h	39.08									
21 c	38.63	38.67	38.56	38.4		37.21	38.09	38.47	38.95	38.48
22 c		39.64	39.7	39.7	39.73	39.34				
23 c	38.98	39.07	39.11	38.96	38.7	38.59	38.42	38.07	38.35	38.36
24 h	38.92	39.47	39.29	39.16		39.03	38.82	38.76	38.82	38.87
25 c		39.42	39.54	39.65	39.62	39.40	38.77	38.43	38.52	38.66
26 h	39.51	39.38	39.08	38.51	37.47	37.66	37.28	37.21	37.52	37.86
28 c*	38.43	38.52	38.56	38.49	38.12	38.01	37.61	37.49	37.52	37.55
32 c	39.53	39.67	39.69	39.58	39.47	39.26	38.79	38.26	38.21	38.24
33 c										
34 h	38.92	38.95	38.9	38.81	38.7	38.22	38.41	38.42	38.34	38.41
35 h*							37.93	37.17		38.06
36 h	39.29	39.35	39.37	39.13	38.72	37.67	37.62	37.77		37.87
37 c	38.89	39.02	38.99	38.98	38.81	38.74	38.67	38.62	38.61	38.62
40 c	38.35	38.48	38.51	38.53	38.49	38.45	38.43	38.4	38.41	38.4
41 h	38.86	38.75	38.66	38.49	38.35	38.24	38.23	38.54	38.69	38.81
	39.79	40.27	40.16	40.02	39.76	39.52	39.24	38.84	38.95	38.92
	39.1	39.3	39.2	39.0	38.9	38.59	38.4	38.2	38.3	38.3

SUBJ	W3T12	W3T15	W4T0	W4T3	W4T6	W4T9	W4T12	W4T15	R2T0	R2T3
1 c			38.66	38.64	38.77	38.92	39.02	39.13	39.23	39.39
5 h			38.98	39.07	39.08	39.08	39.23	39.33	39.29	39.33
6 c	39.65	39.15								
7 c										
9 h	38.26	38.35	38.5	38.63	38.71	38.85	38.92	39.09	39.13	39.2
12 c			37.74	37.41	37.83	38.13	38.35	38.53	38.79	38.98
14 h	38.42	38.48	38.77	38.85	38.92	39.01	39.12	39.19		39.24
15 c	38.54	38.57	38.56	38.57	38.61	38.68	38.78	38.81	38.93	38.92
16 h	37.63	37.91	38.36	38.47	38.64	38.78	38.82	38.93	39	38.98
17 h	38.4	38.48	38.57	38.52	38.57	38.67	38.74	38.73	38.79	38.87
20 h										
21 c	38.51	38.74	38.45							
22 c			37.71	37.28	37.79	38.04		38.32	38.71	39
23 c	38.37	38.39	38.28	38.27	38.37	38.43	38.51	38.60	38.63	38.64
24 h	38.96	39.00	39.19							
25 c	38.72	38.81	39.05	39.1	39.15	39.22		39.28	39.44	39.48
26 h	38.14	38.27	38.62	38.75	38.83	38.86	38.87	38.93	38.97	39.02
28 c*	37.58	37.56	37.63	37.7	38.52	37.8	37.89	37.97	38.17	38.19
32 c	38.26	38.37	38.52	38.61	38.75	39.06	39.22	39.44	39.67	39.82
33 c										
34 h	38.52	38.59	38.84		38.89	38.92	39.01	39.07	39.19	38.6
35 h*	38.11	38.12	38.08	37.88	37.94	37.98	38	38.84	38.15	38.09
36 h	38.01	38.19	38.35	38.44	38.52	38.61	38.73	38.81	38.91	38.98
37 c	38.62	38.17	38.21	38.2	38.22	38.28	38.08	38.39	38.4	38.38
40 c	38.43	38.49	38.56		38.62	38.67	38.7	38.74	38.84	38.89
41 h	38.95	38.93	39	38.84	39.16	39.24	39.32	39.33	39.39	
	39.65	39.15	39.19	39.1	39.16	39.24	39.32	39.44	39.67	39.82
	38.4	38.45	38.5	38.4	38.6	38.7	38.7	38.87	38.9	39.0

SUBJ	R2T6	R2T9	R2T12	R2T15
1 c				
5 h	39.44	39.5	39.29	39.17
6 c	39	38.97	38.89	38.76
7 c				
9 h	39.17	39.04	38.8	38.59
12 c	38.81	38.53	38.36	38.31
14 h	39.25	39.21	39.03	38.83
15 c	38.83	38.72	38.39	38.29
16 h	38.91	38.92	38.75	38.47
17 h	38.85	38.73	38.54	38.40
20 h				
21 c				
22 c	38.92	38.78	38.49	38.28
23 c	38.56	38.39	38.18	38.15
24 h				
25 c	39.43	39.3	38.85	38.46
26 h	38.92	38.78	38.6	
28 c*	38.15	37.99	37.78	37.68
32 c	39.84	39.67	39.47	39.29
33 c				
34 h	39.15	38.9	38.76	38.60
35 h*	38.02	37.88	37.79	37.69
36 h	38.98	38.84	38.58	38.18
37 c	38.25	38.07	37.95	37.83
40 c	38.92	38.92	38.93	38.55
41 h	39.25	39.27	38.98	38.74
	39.84	39.67	39.47	39.29
	38.9	38.8	38.6	38.44

Physiological Strain Index

subject	group	PSIW1	PSIW2	PSIR1	PSIW3	PSIW4	PSIR2	
1 c		7.0		7.8	2.6		8.6	5.7
5 h		5.8			6.3		9.3	4.4
6 c		8.6		9.7	4.8	7.7		
7 c		4.6		5.9	2.1			
9 h		6.8		8.3	2.8	6.2	7.4	3.0
12 c		6.3		9.5	6.7		8.3	3.7
14 h		7.0		7.4	3.9	6.5	8.1	4.7
15 c		6.6		8.0	5.8	6.1	7.2	3.0
16 h		8.4			7.2	2.2	7.0	2.3
17 h		5.3		8.3	5.9	6.5	7.3	4.1
20 h		6.9		8.6				
21 c		6.3		7.6	1.7	8.0		2.9
22 c		6.9		9.4	6.2	4.6	5.7	1.6
23 c		4.3		6.4	4.0		6.2	
24 h		8.0			6.2	8.8		
25 c		6.2		6.1	6.1	6.4	7.0	4.0
26 h		7.9		7.2		4.8	5.2	
32 c		5.1		9.9	5.7	5.5	8.1	5.5
33 c		5.7						
34 h		4.4		7.1	3.6	6.1	7.9	2.4
36 h		5.0		8.2	0.1	3.9	6.6	1.9
37 c		7.5		7.5	4.0	6.3	5.3	1.1
40 c		4.6		6.1	6.6	7.0	7.3	5.9
41 h		4.7		9.0	5.5	8.9	9.4	6.4
	drill 1		drill 2	rehab 1	drill 3	drill 4	rehab 2	
HC		6.4		8.0	4.6	6.0	7.5	3.8
CON		6.1		7.8	4.7	6.4	7.2	3.6
HC stddev		1.4		0.7	2.2	2.1	1.2	1.7
CONstddev		1.3		1.5	1.8	1.1	1.3	1.6

Stroop Test Interference Score

SUBJ	BsIn(CLR-CFLCT)	ENDW1	ENDW2	ENDR1	ENDW3	ENDW4	ENDR2
1 c	48	40	45	50			
5 h	35	33	52	54	50	48	44
6 c	31	46	53	45	55	53	44
7 c	41	45	53	53			
9 h	24	27	42	43		48	36
12 c	24		54	49	53	54	55
14 h	23	23	32	42	35	36	43
15 c	29	21	51	51	54	56	52
16 h	35	49	58	62	54	32	62
17 h	22	46	45	48	36	46	
20 h	57	37	41	45	41	38	48
21 c	31	38	38	37	42	39	40
22 c	39	38	36	41	41	39	44
23 c	2	33	53	40	42	46	51
24 h							
25 c	19	40	23	35	34	37	45
26 h	31	43	40	47	36	51	39
28 c*							
32 c							
33 c	39	43	41	42	47	48	50
34 h	27	31	37	38	32	33	27
35 h*	10	46	40	46	41	30	35
36 h	24	50	57	53	52	52	53
37 c	31	31	60	59	64	55	60
40 c	43	45	46	49		53	
41 h	43	40	50	58	60	65	57
baseline	drill 1	drill 2	drill 3	drill 4	rehab 1	rehab 2	
HC	30	39	49	44	44	44	44
CON	31	38	46	48	48	48	49
HC stdev	12	9	7	10	10	11	11
CON stdev	12	7	7	9	7	7	6

Rating of Perceived Exertion

SUBJ	RPE	ENDW1	ENDW2	ENDR1	ENDW3	ENDW4	ENDR2
1 c	9	15	16	12	19	17	13
5 h	7	19	19	14	17	19	13
6 c	6	15	19	12	7		
7 c	9	17	20	7			
9 h	12	15	18	10	19	13	9
12 c	7	15	19	11	17	19	9
14 h	7	17	17	10	18	15	7
15 c	11	18	20	7	14	15	7
16 h	9	16	17	14	15	16	9
17 h	9	13	18	9	13	15	7
20 h	6	13	17	11	18	18	12
21 c	6	14	13	12	15	16	12
22 c	7	15	17	12	16	18	11
23 c	13	14	18	13	17	17	11
24 h	6	12	15	11	17	16	11
25 c	7	13	17	9	13	17	9
26 h	7	13	18	9	13	20	11
28 c*	6	11	17	7	13	18	11
32 c	7	15	17	6	17	19	9
33 c	6	16	19	9	16	17	9
34 h	6	13	16	9	13	17	9
35 h*	9	15	17	9	14	15	9
36 h	7	14	14	7	13	15	7
37 c	7	13	17	11	16	18	11
40 c	7	16	17	6	17	15	6
41 h	6	12	16				
	baseline	drill 1	drill 2	rehab 1	drill 3	drill 4	rehab 2
HC	8	14	17	10	15	16	9
CON	8	15	18	10	16	18	10
HC std	2	2	1	3	2	2	2
CONstd	2	2	2	2	2	2	2

Perceived Thermal Sensation

SUBJ	PTS	ENDW1	ENDW2	ENDR1	ENDW3	ENDW4	ENDR2	
1 c	4	6	7	7	5	8	7	5
5 h	6	7	6	8	6	7	8	5
6 c	5	6	7	7	5			
7 c	5	7	6	8	5			
9 h	5	6	6	7	5			4
12 c	5	6	6	7	6	7	6	5
14 h	5	7	7	8	4	8	8	
15 c	5	7	7	6	4	7	6	4
16 h	5	6	6	7	4	6	5	3
17 h	5	6	6	6	6	6	7	
20 h	4	6	6	7	4		6	3
21 c	4	6	6	7	5	7	7	5
22 c	2	6	6	7	4	6	6	4
23 c	5	6	6	7	6	6	7	4
24 h	4	6	6	7	6	7		4
25 c	4	6	6	7	6	7	7	6
26 h	4	6	6	7	5	6	7	4
28 c*	3	5	5		4	5	7	5
32 c	4	5	5	6	3	5	7	5
33 c	4	6	6	8	4	6	6	5
34 h	5	5	5	5	3	6	7	4
35 h*	5	6	6	7	3	6	7	3
36 h	5	6	6	5	4	5	6	4
37 c	6	7	7	7	5	7	8	4
40 c	4	6	6	7	4	6	7	
41 h	5	6	6	6	4	7	7	5
baseline								
HC	drill 1	drill 2	drill 3	drill 4	rehab 2			
CON	5	6	5	7	7	rehab 2	4	
HC stdev	4	6	5	7	7		5	
CONstdev	1	1	1	1	1		1	
	1	1	1	1	1		1	

APPENDIX E: STATISTICAL ANALYSIS

T-Test

Group Statistics

EXGRP		N	Mean	Std. Deviation	Std. Error Mean
AGE	1	14	41.43	9.104	2.433
	2	12	40.42	5.915	1.708
HT	1	14	166.371	7.5691	2.0229
	2	12	169.900	6.5818	1.9000
BWPPE	1	14	88.7714	12.36928	3.30583
	2	12	96.5417	17.16182	4.95419
USGPRE	1	14	1.01500	.005023	.001342
	2	12	1.01617	.006322	.001825
USGPost	1	14	1.01793	.007364	.001968
	2	12	1.02233	.006243	.001802
SWL	1	14	2.179	.7670	.2050
	2	12	2.513	.7834	.2261
SWR	1	14	1.089	.3835	.1025
	2	12	1.256	.3917	.1131
PercentDhy	1	14	.7464	.58829	.15723
	2	12	.7792	.91877	.26523
Fluidconsm	1	14	1.5214	.54973	.14692
	2	12	1.7875	.98538	.28445
ESTVO15	1	13	50.9146	7.44606	2.06517
	2	12	51.5150	7.60960	2.19670
Gibsin	1	14	37.286	.2969	.0794
	2	9	37.476	.3989	.1330
HRbsin	1	14	93.429	14.3833	3.8441
	2	12	90.250	13.4646	3.8869
SISbsin	1	12	31.42	12.420	3.585
	2	11	30.09	12.421	3.745
RPEbsin	1	14	7.71	2.091	.559
	2	12	7.58	1.832	.529
PTSbsin	1	14	4.29	.994	.266
	2	12	4.83	.577	.167

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
AGE	Equal variances assumed	2.315	.141	.330	24
	Equal variances not assumed			.340	22.507
HT	Equal variances assumed	.364	.552	-1.257	24
	Equal variances not assumed			-1.271	23.990
BWPPE	Equal variances assumed	2.851	.104	-1.338	24
	Equal variances not assumed			-1.305	19.676
USGPPE	Equal variances assumed	1.540	.227	-.524	24
	Equal variances not assumed			-.515	20.937
USGPost	Equal variances assumed	.322	.576	-1.629	24
	Equal variances not assumed			-1.651	24.000
SWL	Equal variances assumed	.024	.878	-1.096	24
	Equal variances not assumed			-1.094	23.232
SWR	Equal variances assumed	.024	.878	-1.096	24
	Equal variances not assumed			-1.094	23.232
PercentDhy	Equal variances assumed	2.805	.107	-.110	24
	Equal variances not assumed			-.106	18.189
Fluidconsmd	Equal variances assumed	7.856	.010	-.867	24
	Equal variances not assumed			-.831	16.649
ESTVO15	Equal variances assumed	.639	.432	-.199	23
	Equal variances not assumed			-.199	22.748
Gibslin	Equal variances assumed	.807	.379	-1.309	21

Independent Samples Test

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
AGE	Equal variances assumed	.745	1.012	3.071
	Equal variances not assumed	.737	1.012	2.973
HT	Equal variances assumed	.221	-3.5286	2.8063
	Equal variances not assumed	.216	-3.5286	2.7753
BWPPE	Equal variances assumed	.193	-7.77024	5.80667
	Equal variances not assumed	.207	-7.77024	5.95588
USGPRE	Equal variances assumed	.605	-.001167	.002225
	Equal variances not assumed	.612	-.001167	.002266
USGPost	Equal variances assumed	.116	-.004405	.002704
	Equal variances not assumed	.112	-.004405	.002668
SWL	Equal variances assumed	.284	-.3339	.3047
	Equal variances not assumed	.285	-.3339	.3052
SWR	Equal variances assumed	.284	-.1670	.1524
	Equal variances not assumed	.285	-.1670	.1526
PercentDhy	Equal variances assumed	.913	-.03274	.29814
	Equal variances not assumed	.917	-.03274	.30833
Fluidconsm	Equal variances assumed	.395	-.26607	.30693
	Equal variances not assumed	.418	-.26607	.32016
ESTVO15	Equal variances assumed	.844	-.60038	3.01230
	Equal variances not assumed	.844	-.60038	3.01503
Gibsln	Equal variances assumed	.205	-.1898	.1450

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
AGE	Equal variances assumed	-5.326	7.350
	Equal variances not assumed	-5.145	7.169
HT	Equal variances assumed	-9.3206	2.2634
	Equal variances not assumed	-9.2566	2.1995
BWPPE	Equal variances assumed	-19.75462	4.21414
	Equal variances not assumed	-20.20712	4.66665
USGPPE	Equal variances assumed	-.005759	.003425
	Equal variances not assumed	-.005879	.003546
USGPost	Equal variances assumed	-.009985	.001175
	Equal variances not assumed	-.009912	.001103
SWL	Equal variances assumed	-.9628	.2950
	Equal variances not assumed	-.9650	.2971
SWR	Equal variances assumed	-.4814	.1475
	Equal variances not assumed	-.4825	.1486
PercentDhy	Equal variances assumed	-.64807	.58260
	Equal variances not assumed	-.68003	.61455
Fluidconsm	Equal variances assumed	-.89954	.36740
	Equal variances not assumed	-.94263	.41048
ESTVO15	Equal variances assumed	-6.83180	5.63103
	Equal variances not assumed	-6.84128	5.64051
Gibsl	Equal variances assumed	-.4914	.1117

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Glbsln	Equal variances not assumed			-1.226	13.648
HRbsln	Equal variances assumed	.025	.876	.578	24
	Equal variances not assumed			.581	23.787
SISbsln	Equal variances assumed	.012	.914	.256	21
	Equal variances not assumed			.256	20.826
RPEbsln	Equal variances assumed	.101	.753	.168	24
	Equal variances not assumed			.170	23.981
PTSbsln	Equal variances assumed	2.750	.110	-1.678	24
	Equal variances not assumed			-1.746	21.335

Independent Samples Test

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Glbsln	Equal variances not assumed	.241	-.1898	.1548
HRbsln	Equal variances assumed	.568	3.1786	5.4957
	Equal variances not assumed	.566	3.1786	5.4667
SISbsln	Equal variances assumed	.801	1.326	5.185
	Equal variances not assumed	.801	1.326	5.185
RPEbsln	Equal variances assumed	.868	.131	.778
	Equal variances not assumed	.866	.131	.769
PTSbsln	Equal variances assumed	.106	-.548	.326
	Equal variances not assumed	.095	-.548	.314

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Glbsln	Equal variances not assumed	-.5228	.1431
HRbsln	Equal variances assumed	-8.1639	14.5211
	Equal variances not assumed	-8.1095	14.4667
SISbsln	Equal variances assumed	-9.457	12.108
	Equal variances not assumed	-9.462	12.114
RPEbsln	Equal variances assumed	-1.474	1.736
	Equal variances not assumed	-1.457	1.719
PTSbsln	Equal variances assumed	-1.221	.126
	Equal variances not assumed	-1.199	.104

T-Test

Group Statistics

EXPGRP		N	Mean	Std. Deviation	Std. Error Mean
ESTVO15	1	12	50.2200	7.32405	2.11427
	2	11	52.1864	7.59914	2.29123
HRbsln	1	13	93.923	14.8462	4.1176
	2	11	88.091	11.7427	3.5406

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
ESTVO15	Equal variances assumed	.676	.420	-.632	21
	Equal variances not assumed			-.631	20.662
HRbsln	Equal variances assumed	.113	.740	1.053	22
	Equal variances not assumed			1.074	21.923

Independent Samples Test

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
ESTVO15	Equal variances assumed	.534	-1.96636	3.11244
	Equal variances not assumed	.535	-1.96636	3.11767
HRbsln	Equal variances assumed	.304	5.8322	5.5405
	Equal variances not assumed	.295	5.8322	5.4305

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
ESTVO15	Equal variances assumed	-8.43903	4.50631
	Equal variances not assumed	-8.45638	4.52365
HRbsln	Equal variances assumed	-5.6581	17.3224
	Equal variances not assumed	-5.4323	17.0966

General Linear Model

Within-Subjects
Factors

Measure: MEASURE_1

time	Dependent Variable
1	GIW1T0
2	GIW1T15
3	GIW2T15
4	GIR1T15
5	GIW3T15
6	GIW4T15
7	GIR2T15

Between-Subjects
Factors

	N
EXPGRP 1	10
2	9

Descriptive Statistics

EXPGRP		Mean	Std. Deviation	N
GIW1T0	1	37.6050	.37807	10
	2	37.7100	.28605	9
	Total	37.6547	.33277	19
GIW1T15	1	38.1700	.43972	10
	2	38.4356	.40651	9
	Total	38.2958	.43437	19
GIW2T15	1	39.0880	.51233	10
	2	39.2822	.46464	9
	Total	39.1800	.48695	19
GIR1T15	1	38.8590	.43437	10
	2	38.4678	.66998	9
	Total	38.6737	.57803	19
GIW3T15	1	38.4930	.44322	10
	2	38.4578	.33048	9
	Total	38.4763	.38352	19
GIW4T15	1	38.7410	.48190	10
	2	39.0233	.19000	9
	Total	38.8747	.39133	19
GIR2T15	1	38.3600	.45609	10
	2	38.6200	.28000	9
	Total	38.4832	.39578	19

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.069	39.606	20	.006

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

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

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Epsilon ^a		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.589	.806	.167

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

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

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

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	26.300	6	4.383	39.029
	Greenhouse-Geisser	26.300	3.534	7.443	39.029
	Huynh-Feldt	26.300	4.837	5.437	39.029
	Lower-bound	26.300	1.000	26.300	39.029
time * EXPGRP	Sphericity Assumed	1.680	6	.280	2.493
	Greenhouse-Geisser	1.680	3.534	.475	2.493
	Huynh-Feldt	1.680	4.837	.347	2.493
	Lower-bound	1.680	1.000	1.680	2.493
Error(time)	Sphericity Assumed	11.456	102	.112	
	Greenhouse-Geisser	11.456	60.072	.191	
	Huynh-Feldt	11.456	82.232	.139	
	Lower-bound	11.456	17.000	.674	

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^a
time	Sphericity Assumed	.000	.697	234.173	1.000
	Greenhouse-Geisser	.000	.697	137.913	1.000
	Huynh-Feldt	.000	.697	188.788	1.000
	Lower-bound	.000	.697	39.029	1.000
time * EXPGRP	Sphericity Assumed	.027	.128	14.960	.815
	Greenhouse-Geisser	.059	.128	8.810	.638
	Huynh-Feldt	.039	.128	12.060	.745
	Lower-bound	.133	.128	2.493	.320

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	196821.306	1	196821.306	320299.690	.000	1.000
EXPGRP	.314	1	.314	.510	.485	.029
Error	10.446	17	.614			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Noncent. Parameter	Observed Power ^a
Intercept	320299.690	1.000
EXPGRP	.510	.104

a. Computed using alpha = .05

Profile Plots

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GIW1T15	38.3388	24	.43140	.08806
	GIW2T15	39.1408	24	.46662	.09525
Pair 2	GIW1T15	38.3226	23	.43362	.09042
	GIR1T15	38.5917	23	.62060	.12940
Pair 3	GIW1T15	38.2991	22	.41307	.08807
	GIW3T15	38.4959	22	.38483	.08205
Pair 4	GIW1T15	38.2940	20	.42286	.09456
	GIW4T15	38.8730	20	.38097	.08519
Pair 5	GIW1T15	38.2940	20	.42286	.09456
	GIR2T15	38.4435	20	.42409	.09483
Pair 6	GIW2T15	39.1539	23	.47259	.09854
	GIR1T15	38.5917	23	.62060	.12940
Pair 7	GIW2T15	39.1624	21	.49093	.10713
	GIW3T15	38.5138	21	.38483	.08398
Pair 8	GIW2T15	39.1800	19	.48695	.11171
	GIW4T15	38.8747	19	.39133	.08978
Pair 9	GIW2T15	39.1800	19	.48695	.11171
	GIR2T15	38.4832	19	.39578	.09080
Pair 10	GIR1T15	38.6210	21	.64129	.13994
	GIW3T15	38.5138	21	.38483	.08398
Pair 11	GIR1T15	38.6737	19	.57803	.13261
	GIW4T15	38.8747	19	.39133	.08978
Pair 12	GIR1T15	38.6737	19	.57803	.13261
	GIR2T15	38.4832	19	.39578	.09080
Pair 13	GIW3T15	38.4585	20	.38170	.08535
	GIW4T15	38.8730	20	.38097	.08519
Pair 14	GIW3T15	38.4585	20	.38170	.08535
	GIR2T15	38.4435	20	.42409	.09483
Pair 15	GIW4T15	38.8730	20	.38097	.08519
	GIR2T15	38.4435	20	.42409	.09483
Pair 16	GIW1T0	37.6631	26	.31082	.06096
	GIW1T15	38.3231	26	.41897	.08217
Pair 17	GIW1T0	37.6746	24	.30754	.06278
	GIW2T15	39.1408	24	.46662	.09525
Pair 18	GIW1T0	37.6770	23	.31423	.06552
	GIR1T15	38.5917	23	.62060	.12940
Pair 19	GIW1T0	37.6800	22	.32279	.06882
	GIW3T15	38.4959	22	.38483	.08205

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 20	GIW1T0	37.6640	20	.32654	.07302
	GIW4T15	38.8730	20	.38097	.08519
Pair 21	GIW1T0	37.6640	20	.32654	.07302
	GIR2T15	38.4435	20	.42409	.09483

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	GIW1T15 & GIW2T15	24	.750	.000
Pair 2	GIW1T15 & GIR1T15	23	.200	.360
Pair 3	GIW1T15 & GIW3T15	22	.189	.399
Pair 4	GIW1T15 & GIW4T15	20	.328	.158
Pair 5	GIW1T15 & GIR2T15	20	.213	.367
Pair 6	GIW2T15 & GIR1T15	23	.568	.005
Pair 7	GIW2T15 & GIW3T15	21	.205	.372
Pair 8	GIW2T15 & GIW4T15	19	.433	.064
Pair 9	GIW2T15 & GIR2T15	19	.392	.097
Pair 10	GIR1T15 & GIW3T15	21	.256	.263
Pair 11	GIR1T15 & GIW4T15	19	.172	.482
Pair 12	GIR1T15 & GIR2T15	19	.300	.212
Pair 13	GIW3T15 & GIW4T15	20	.512	.021
Pair 14	GIW3T15 & GIR2T15	20	.555	.011
Pair 15	GIW4T15 & GIR2T15	20	.780	.000
Pair 16	GIW1T0 & GIW1T15	26	.571	.002
Pair 17	GIW1T0 & GIW2T15	24	.478	.018
Pair 18	GIW1T0 & GIR1T15	23	.133	.546
Pair 19	GIW1T0 & GIW3T15	22	.248	.267
Pair 20	GIW1T0 & GIW4T15	20	.321	.168
Pair 21	GIW1T0 & GIR2T15	20	.118	.620

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	GIW1T15 - GIW2T15	-.80208	.31951	.06522
Pair 2	GIW1T15 - GIR1T15	-.26913	.68233	.14228
Pair 3	GIW1T15 - GIW3T15	-.19682	.50847	.10841
Pair 4	GIW1T15 - GIW4T15	-.57900	.46708	.10444
Pair 5	GIW1T15 - GIR2T15	-.14950	.53132	.11881
Pair 6	GIW2T15 - GIR1T15	.56217	.52472	.10941
Pair 7	GIW2T15 - GIW3T15	.64857	.55809	.12178
Pair 8	GIW2T15 - GIW4T15	.30526	.47442	.10884
Pair 9	GIW2T15 - GIR2T15	.69684	.49271	.11304
Pair 10	GIR1T15 - GIW3T15	.10714	.65801	.14359
Pair 11	GIR1T15 - GIW4T15	-.20105	.63994	.14681
Pair 12	GIR1T15 - GIR2T15	.19053	.59450	.13639
Pair 13	GIW3T15 - GIW4T15	-.41450	.37691	.08428
Pair 14	GIW3T15 - GIR2T15	.01500	.38213	.08545
Pair 15	GIW4T15 - GIR2T15	.42950	.27010	.06040
Pair 16	GIW1T0 - GIW1T15	-.66000	.35135	.06891
Pair 17	GIW1T0 - GIW2T15	-1.46625	.41834	.08539
Pair 18	GIW1T0 - GIR1T15	-.91478	.65738	.13707
Pair 19	GIW1T0 - GIW3T15	-.81591	.43677	.09312
Pair 20	GIW1T0 - GIW4T15	-1.20900	.41466	.09272
Pair 21	GIW1T0 - GIR2T15	-.77950	.50379	.11265

Paired Samples Test

		Paired Differences		t
		95% Confidence Interval of the Difference		
		Lower	Upper	
Pair 1	GIW1T15 - GIW2T15	-.93700	-.66717	-12.298
Pair 2	GIW1T15 - GIR1T15	-.56419	.02593	-1.892
Pair 3	GIW1T15 - GIW3T15	-.42226	.02862	-1.816
Pair 4	GIW1T15 - GIW4T15	-.79760	-.36040	-5.544
Pair 5	GIW1T15 - GIR2T15	-.39816	.09916	-1.258
Pair 6	GIW2T15 - GIR1T15	.33527	.78908	5.138
Pair 7	GIW2T15 - GIW3T15	.39453	.90261	5.326
Pair 8	GIW2T15 - GIW4T15	.07660	.53392	2.805
Pair 9	GIW2T15 - GIR2T15	.45936	.93432	6.165
Pair 10	GIR1T15 - GIW3T15	-.19238	.40666	.746
Pair 11	GIR1T15 - GIW4T15	-.50949	.10739	-1.369
Pair 12	GIR1T15 - GIR2T15	-.09601	.47707	1.397
Pair 13	GIW3T15 - GIW4T15	-.59090	-.23810	-4.918
Pair 14	GIW3T15 - GIR2T15	-.16384	.19384	.176
Pair 15	GIW4T15 - GIR2T15	.30309	.55591	7.111
Pair 16	GIW1T0 - GIW1T15	-.80191	-.51809	-9.578
Pair 17	GIW1T0 - GIW2T15	-1.64290	-1.28960	-17.171
Pair 18	GIW1T0 - GIR1T15	-1.19906	-.63051	-6.674
Pair 19	GIW1T0 - GIW3T15	-1.00956	-.62226	-8.762
Pair 20	GIW1T0 - GIW4T15	-1.40307	-1.01493	-13.039
Pair 21	GIW1T0 - GIR2T15	-1.01528	-.54372	-6.920

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	GIW1T15 - GIW2T15	23	.000
Pair 2	GIW1T15 - GIR1T15	22	.072
Pair 3	GIW1T15 - GIW3T15	21	.084
Pair 4	GIW1T15 - GIW4T15	19	.000
Pair 5	GIW1T15 - GIR2T15	19	.224
Pair 6	GIW2T15 - GIR1T15	22	.000
Pair 7	GIW2T15 - GIW3T15	20	.000
Pair 8	GIW2T15 - GIW4T15	18	.012
Pair 9	GIW2T15 - GIR2T15	18	.000
Pair 10	GIR1T15 - GIW3T15	20	.464
Pair 11	GIR1T15 - GIW4T15	18	.188
Pair 12	GIR1T15 - GIR2T15	18	.179
Pair 13	GIW3T15 - GIW4T15	19	.000
Pair 14	GIW3T15 - GIR2T15	19	.863
Pair 15	GIW4T15 - GIR2T15	19	.000
Pair 16	GIW1T0 - GIW1T15	25	.000
Pair 17	GIW1T0 - GIW2T15	23	.000
Pair 18	GIW1T0 - GIR1T15	22	.000
Pair 19	GIW1T0 - GIW3T15	21	.000
Pair 20	GIW1T0 - GIW4T15	19	.000
Pair 21	GIW1T0 - GIR2T15	19	.000

General Linear Model

Within-Subjects
Factors

Measure: MEASURE_1

time	Dependent Variable
1	HRW1T0
2	HRW1T15
3	HRW2T15
4	HRR1T15
5	HRW3T15
6	HRW4T15
7	HRR2T15

Between-Subjects
Factors

	N
EXPGRP 1	11
2	7

Descriptive Statistics

EXPGRP	Mean	Std. Deviation	N
HRW1T0 1	120.5455	28.22185	11
2	116.2857	16.50974	7
Total	118.8889	23.85961	18
HRW1T15 1	163.3636	16.21896	11
2	157.4286	20.83952	7
Total	161.0556	17.80110	18
HRW2T15 1	162.2727	26.25297	11
2	166.2857	15.29395	7
Total	163.8333	22.18174	18
HRR1T15 1	125.9091	19.23255	11
2	117.0000	22.68627	7
Total	122.4444	20.47444	18
HRW3T15 1	155.3636	19.08021	11
2	155.2857	17.33700	7
Total	155.3333	17.89512	18
HRW4T15 1	156.1818	17.96006	11
2	159.2857	8.38082	7
Total	157.3889	14.72948	18
HRR2T15 1	115.2727	18.87904	11
2	106.7143	19.44834	7
Total	111.9444	19.01539	18

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.112	30.162	20	.073

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

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

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Epsilon ^a		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.617	.877	.167

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

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

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

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	54677.734	6	9112.956	44.559
	Greenhouse-Geisser	54677.734	3.704	14760.234	44.559
	Huynh-Feldt	54677.734	5.260	10394.327	44.559
	Lower-bound	54677.734	1.000	54677.734	44.559
time * EXPGRP	Sphericity Assumed	731.384	6	121.897	.596
	Greenhouse-Geisser	731.384	3.704	197.437	.596
	Huynh-Feldt	731.384	5.260	139.037	.596
	Lower-bound	731.384	1.000	731.384	.596
Error(time)	Sphericity Assumed	19633.250	96	204.513	
	Greenhouse-Geisser	19633.250	59.270	331.249	
	Huynh-Feldt	19633.250	84.165	233.270	
	Lower-bound	19633.250	16.000	1227.078	

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^a
time	Sphericity Assumed	.000	.736	267.356	1.000
	Greenhouse-Geisser	.000	.736	165.065	1.000
	Huynh-Feldt	.000	.736	234.397	1.000
	Lower-bound	.000	.736	44.559	1.000
time * EXPGRP	Sphericity Assumed	.733	.036	3.576	.228
	Greenhouse-Geisser	.654	.036	2.208	.180
	Huynh-Feldt	.711	.036	3.135	.213
	Lower-bound	.451	.036	.596	.112

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	2.389E6	1	2.389E6	1516.214	.000	.990
EXPGRP	259.920	1	259.920	.165	.690	.010
Error	25210.334	16	1575.646			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Noncent. Parameter	Observed Power ^a
Intercept	1516.214	1.000
EXPGRP	.165	.067

a. Computed using alpha = .05

Profile Plots

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	HRW1T15	161.3143	35	15.88890	2.68571
	HRW2T15	160.6857	35	21.71171	3.66995
Pair 2	HRW1T15	161.3714	35	15.86169	2.68112
	HRR1T15	114.5714	35	19.39874	3.27898
Pair 3	HRW1T15	162.0000	33	16.07405	2.79813
	HRW3T15	158.2727	33	16.24091	2.82718
Pair 4	HRW1T15	161.0909	33	15.45227	2.68990
	HRW4T15	158.1818	33	13.48484	2.34741
Pair 5	HRW1T15	160.9063	32	15.66249	2.76876
	HRR2T15	104.0000	32	18.88676	3.33874
Pair 6	HRW2T15	160.1176	34	21.77261	3.73397
	HRR1T15	115.2647	34	19.24532	3.30055
Pair 7	HRW2T15	161.0313	32	21.86835	3.86581
	HRW3T15	157.4688	32	15.81952	2.79652
Pair 8	HRW2T15	160.8438	32	21.65434	3.82798
	HRW4T15	158.1875	32	13.70057	2.42194
Pair 9	HRW2T15	161.6129	31	21.56336	3.87289
	HRR2T15	104.0000	31	19.19896	3.44823
Pair 10	HRR1T15	115.3438	32	19.99292	3.53428
	HRW3T15	158.0313	32	16.44048	2.90629
Pair 11	HRR1T15	114.5938	32	19.48177	3.44392
	HRW4T15	157.6875	32	13.39340	2.36764
Pair 12	HRR1T15	115.0645	31	19.61791	3.52348
	HRR2T15	104.4194	31	19.04691	3.42093
Pair 13	HRW3T15	157.5000	32	15.87248	2.80588
	HRW4T15	157.6875	32	13.39340	2.36764
Pair 14	HRW3T15	157.7419	31	16.07476	2.88711
	HRR2T15	103.3871	31	18.87269	3.38964
Pair 15	HRW4T15	159.0625	32	12.69985	2.24504
	HRR2T15	104.0000	32	18.88676	3.33874
Pair 16	HRW1T0	118.6857	35	19.03367	3.21728
	HRW1T15	161.9143	35	15.20908	2.57080
Pair 17	HRW1T0	118.6765	34	19.31983	3.31332
	HRW2T15	161.0588	34	21.92403	3.75994
Pair 18	HRW1T0	118.9118	34	19.27216	3.30515
	HRR1T15	114.6765	34	19.68036	3.37515
Pair 19	HRW1T0	118.8750	32	19.78880	3.49820
	HRW3T15	158.7188	32	16.29414	2.88042

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 20	HRW1T0	118.0938	32	19.50080	3.44729
	HRW4T15	158.1875	32	13.70057	2.42194
Pair 21	HRW1T0	118.8387	31	19.35475	3.47622
	HRR2T15	105.0968	31	18.13350	3.25687

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	HRW1T15 & HRW2T15	35	.149	.393
Pair 2	HRW1T15 & HRR1T15	35	.300	.080
Pair 3	HRW1T15 & HRW3T15	33	.426	.013
Pair 4	HRW1T15 & HRW4T15	33	.202	.259
Pair 5	HRW1T15 & HRR2T15	32	.298	.098
Pair 6	HRW2T15 & HRR1T15	34	.484	.004
Pair 7	HRW2T15 & HRW3T15	32	.409	.020
Pair 8	HRW2T15 & HRW4T15	32	.521	.002
Pair 9	HRW2T15 & HRR2T15	31	.441	.013
Pair 10	HRR1T15 & HRW3T15	32	.385	.030
Pair 11	HRR1T15 & HRW4T15	32	.357	.045
Pair 12	HRR1T15 & HRR2T15	31	.751	.000
Pair 13	HRW3T15 & HRW4T15	32	.511	.003
Pair 14	HRW3T15 & HRR2T15	31	.459	.009
Pair 15	HRW4T15 & HRR2T15	32	.364	.041
Pair 16	HRW1T0 & HRW1T15	35	.514	.002
Pair 17	HRW1T0 & HRW2T15	34	.340	.049
Pair 18	HRW1T0 & HRR1T15	34	.507	.002
Pair 19	HRW1T0 & HRW3T15	32	.597	.000
Pair 20	HRW1T0 & HRW4T15	32	.548	.001
Pair 21	HRW1T0 & HRR2T15	31	.584	.001

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	HRW1T15 - HRW2T15	.62857	24.91997	4.21224
Pair 2	HRW1T15 - HRR1T15	46.80000	21.05148	3.55835
Pair 3	HRW1T15 - HRW3T15	3.72727	17.31017	3.01331
Pair 4	HRW1T15 - HRW4T15	2.90909	18.33774	3.19219
Pair 5	HRW1T15 - HRR2T15	56.90625	20.63564	3.64790
Pair 6	HRW2T15 - HRR1T15	44.85294	20.94746	3.59246
Pair 7	HRW2T15 - HRW3T15	3.56250	21.10181	3.73031
Pair 8	HRW2T15 - HRW4T15	2.65625	18.64543	3.29608
Pair 9	HRW2T15 - HRR2T15	57.61290	21.64667	3.88786
Pair 10	HRR1T15 - HRW3T15	-42.68750	20.42206	3.61014
Pair 11	HRR1T15 - HRW4T15	-43.09375	19.30462	3.41261
Pair 12	HRR1T15 - HRR2T15	10.64516	13.66638	2.45455
Pair 13	HRW3T15 - HRW4T15	-.18750	14.62750	2.58580
Pair 14	HRW3T15 - HRR2T15	54.35484	18.33675	3.29338
Pair 15	HRW4T15 - HRR2T15	55.06250	18.52973	3.27562
Pair 16	HRW1T0 - HRW1T15	-43.22857	17.20309	2.90785
Pair 17	HRW1T0 - HRW2T15	-42.38235	23.79587	4.08096
Pair 18	HRW1T0 - HRR1T15	4.23529	19.33604	3.31610
Pair 19	HRW1T0 - HRW3T15	-39.84375	16.48677	2.91448
Pair 20	HRW1T0 - HRW4T15	-40.09375	16.58091	2.93112
Pair 21	HRW1T0 - HRR2T15	13.74194	17.13664	3.07783

Paired Samples Test

		Paired Differences		t
		95% Confidence Interval of the Difference		
		Lower	Upper	
Pair 1	HRW1T15 - HRW2T15	-7.93174	9.18888	.149
Pair 2	HRW1T15 - HRR1T15	39.56856	54.03144	13.152
Pair 3	HRW1T15 - HRW3T15	-2.41065	9.86519	1.237
Pair 4	HRW1T15 - HRW4T15	-3.59319	9.41137	.911
Pair 5	HRW1T15 - HRR2T15	49.46631	64.34619	15.600
Pair 6	HRW2T15 - HRR1T15	37.54403	52.16185	12.485
Pair 7	HRW2T15 - HRW3T15	-4.04551	11.17051	.955
Pair 8	HRW2T15 - HRW4T15	-4.06615	9.37865	.806
Pair 9	HRW2T15 - HRR2T15	49.67284	65.55297	14.819
Pair 10	HRR1T15 - HRW3T15	-50.05044	-35.32456	-11.824
Pair 11	HRR1T15 - HRW4T15	-50.05381	-36.13369	-12.628
Pair 12	HRR1T15 - HRR2T15	5.63229	15.65803	4.337
Pair 13	HRW3T15 - HRW4T15	-5.46128	5.08628	-.073
Pair 14	HRW3T15 - HRR2T15	47.62886	61.08081	16.504
Pair 15	HRW4T15 - HRR2T15	48.38182	61.74318	16.810
Pair 16	HRW1T0 - HRW1T15	-49.13804	-37.31910	-14.866
Pair 17	HRW1T0 - HRW2T15	-50.68512	-34.07958	-10.385
Pair 18	HRW1T0 - HRR1T15	-2.51137	10.98196	1.277
Pair 19	HRW1T0 - HRW3T15	-45.78786	-33.89964	-13.671
Pair 20	HRW1T0 - HRW4T15	-46.07180	-34.11570	-13.679
Pair 21	HRW1T0 - HRR2T15	7.45616	20.02771	4.465

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	HRW1T15 - HRW2T15	34	.882
Pair 2	HRW1T15 - HRR1T15	34	.000
Pair 3	HRW1T15 - HRW3T15	32	.225
Pair 4	HRW1T15 - HRW4T15	32	.369
Pair 5	HRW1T15 - HRR2T15	31	.000
Pair 6	HRW2T15 - HRR1T15	33	.000
Pair 7	HRW2T15 - HRW3T15	31	.347
Pair 8	HRW2T15 - HRW4T15	31	.426
Pair 9	HRW2T15 - HRR2T15	30	.000
Pair 10	HRR1T15 - HRW3T15	31	.000
Pair 11	HRR1T15 - HRW4T15	31	.000
Pair 12	HRR1T15 - HRR2T15	30	.000
Pair 13	HRW3T15 - HRW4T15	31	.943
Pair 14	HRW3T15 - HRR2T15	30	.000
Pair 15	HRW4T15 - HRR2T15	31	.000
Pair 16	HRW1T0 - HRW1T15	34	.000
Pair 17	HRW1T0 - HRW2T15	33	.000
Pair 18	HRW1T0 - HRR1T15	33	.210
Pair 19	HRW1T0 - HRW3T15	31	.000
Pair 20	HRW1T0 - HRW4T15	31	.000
Pair 21	HRW1T0 - HRR2T15	30	.000

General Linear Model

Within-Subjects
Factors

Measure: MEASURE_1

time	Dependent Variable
1	PSIW1
2	PSIW2
3	PSIR1
4	PSIW3
5	PSIW4
6	PSIR2

Between-Subjects
Factors

	N
EXGRP 1	7
2	6

Descriptive Statistics

EXPGRP		Mean	Std. Deviation	N
PSIW1	1	6.1286	1.57873	7
	2	5.5333	1.10212	6
	Total	5.8538	1.35930	13
PSIW2	1	7.6714	1.62143	7
	2	8.0500	.68920	6
	Total	7.8462	1.24540	13
PSIR1	1	5.2857	1.03026	7
	2	3.6333	2.09157	6
	Total	4.5231	1.75744	13
PSIW3	1	6.2286	.99952	7
	2	6.3500	1.58965	6
	Total	6.2846	1.24756	13
PSIW4	1	7.2000	1.28323	7
	2	7.7833	.94956	6
	Total	7.4692	1.13606	13
PSIR2	1	3.6429	1.83925	7
	2	3.7500	1.66463	6
	Total	3.6923	1.68793	13

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.088	22.154	14	.084

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

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

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Epsilon ^a		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.503	.723	.200

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

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

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

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	173.894	5	34.779	26.699
	Greenhouse-Geisser	173.894	2.513	69.192	26.699
	Huynh-Feldt	173.894	3.614	48.116	26.699
	Lower-bound	173.894	1.000	173.894	26.699
time * EXPGRP	Sphericity Assumed	11.011	5	2.202	1.691
	Greenhouse-Geisser	11.011	2.513	4.381	1.691
	Huynh-Feldt	11.011	3.614	3.047	1.691
	Lower-bound	11.011	1.000	11.011	1.691
Error(time)	Sphericity Assumed	71.646	55	1.303	
	Greenhouse-Geisser	71.646	27.645	2.592	
	Huynh-Feldt	71.646	39.755	1.802	
	Lower-bound	71.646	11.000	6.513	

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^a
time	Sphericity Assumed	.000	.708	133.493	1.000
	Greenhouse-Geisser	.000	.708	67.100	1.000
	Huynh-Feldt	.000	.708	96.491	1.000
	Lower-bound	.000	.708	26.699	.997
time * EXPGRP	Sphericity Assumed	.152	.133	8.453	.543
	Greenhouse-Geisser	.198	.133	4.249	.361
	Huynh-Feldt	.176	.133	6.110	.448
	Lower-bound	.220	.133	1.691	.221

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	2734.082	1	2734.082	477.813	.000	.977
EXPGRP	.602	1	.602	.105	.752	.009
Error	62.943	11	5.722			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Noncent. Parameter	Observed Power ^a
Intercept	477.813	1.000
EXPGRP	.105	.060

a. Computed using alpha = .05

Profile Plots

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PSIW1	6.2964	28	1.30568	.24675
	PSIW2	8.0107	28	1.45966	.27585
Pair 2	PSIW1	6.3192	26	1.29924	.25480
	PSIR1	3.9654	26	2.27806	.44676
Pair 3	PSIW1	6.3556	27	1.30187	.25055
	PSIW3	6.0333	27	1.40548	.27049
Pair 4	PSIW1	6.2964	28	1.24528	.23534
	PSIW4	7.4321	28	1.14279	.21597
Pair 5	PSIW1	6.0818	22	1.27975	.27284
	PSIR2	3.0727	22	1.87520	.39979
Pair 6	PSIW2	8.0318	22	1.21200	.25840
	PSIR1	3.7682	22	2.13773	.45577
Pair 7	PSIW2	7.9182	22	1.50480	.32082
	PSIW3	6.1318	22	1.12096	.23899
Pair 8	PSIW2	8.0652	23	1.53226	.31950
	PSIW4	7.4130	23	1.17446	.24489
Pair 9	PSIW2	7.9158	19	1.59592	.36613
	PSIR2	3.0158	19	1.91028	.43825

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 10	PSIR1	3.7714	21	2.29873	.50162
	PSIW3	6.1476	21	1.53936	.33592
Pair 11	PSIR1	4.1136	22	2.32774	.49628
	PSIW4	7.4864	22	1.06962	.22804
Pair 12	PSIR1	4.5895	19	2.10420	.48274
	PSIR2	3.3105	19	1.87317	.42974
Pair 13	PSIW3	5.8440	25	1.27380	.25476
	PSIW4	7.4200	25	1.12064	.22413
Pair 14	PSIW3	6.0053	19	1.40968	.32340
	PSIR2	2.9105	19	1.91511	.43936
Pair 15	PSIW4	7.4818	22	1.05724	.22540
	PSIR2	3.0727	22	1.87520	.39979

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PSIW1 & PSIW2	28	.423	.025
Pair 2	PSIW1 & PSIR1	26	-.006	.975
Pair 3	PSIW1 & PSIW3	27	-.060	.765
Pair 4	PSIW1 & PSIW4	28	-.094	.636
Pair 5	PSIW1 & PSIR2	22	-.165	.464
Pair 6	PSIW2 & PSIR1	22	.053	.815
Pair 7	PSIW2 & PSIW3	22	.212	.343
Pair 8	PSIW2 & PSIW4	23	.455	.029
Pair 9	PSIW2 & PSIR2	19	.316	.187
Pair 10	PSIR1 & PSIW3	21	.177	.442
Pair 11	PSIR1 & PSIW4	22	.041	.856
Pair 12	PSIR1 & PSIR2	19	.646	.003
Pair 13	PSIW3 & PSIW4	25	.483	.014
Pair 14	PSIW3 & PSIR2	19	.484	.036
Pair 15	PSIW4 & PSIR2	22	.574	.005

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PSIW1 - PSIW2	-1.71429	1.49163	.28189
Pair 2	PSIW1 - PSIR1	2.35385	2.62971	.51573
Pair 3	PSIW1 - PSIW3	.32222	1.97257	.37962
Pair 4	PSIW1 - PSIW4	-1.13571	1.76724	.33398
Pair 5	PSIW1 - PSIR2	3.00909	2.43798	.51978
Pair 6	PSIW2 - PSIR1	4.26364	2.40090	.51187
Pair 7	PSIW2 - PSIW3	1.78636	1.67483	.35707
Pair 8	PSIW2 - PSIW4	.65217	1.44564	.30144
Pair 9	PSIW2 - PSIR2	4.90000	2.06559	.47388
Pair 10	PSIR1 - PSIW3	-2.37619	2.52961	.55201
Pair 11	PSIR1 - PSIW4	-3.37273	2.52137	.53756
Pair 12	PSIR1 - PSIR2	1.27895	1.68575	.38674
Pair 13	PSIW3 - PSIW4	-1.57600	1.22416	.24483
Pair 14	PSIW3 - PSIR2	3.09474	1.74467	.40025
Pair 15	PSIW4 - PSIR2	4.40909	1.53620	.32752

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	PSIW1 - PSIW2	-2.29268	-1.13589	-6.081	27	.000
Pair 2	PSIW1 - PSIR1	1.29168	3.41601	4.564	25	.000
Pair 3	PSIW1 - PSIW3	-.45810	1.10254	.849	26	.404
Pair 4	PSIW1 - PSIW4	-1.82098	-.45045	-3.401	27	.002
Pair 5	PSIW1 - PSIR2	1.92815	4.09003	5.789	21	.000
Pair 6	PSIW2 - PSIR1	3.19914	5.32814	8.329	21	.000
Pair 7	PSIW2 - PSIW3	1.04379	2.52894	5.003	21	.000
Pair 8	PSIW2 - PSIW4	.02703	1.27732	2.164	22	.042
Pair 9	PSIW2 - PSIR2	3.90442	5.89558	10.340	18	.000
Pair 10	PSIR1 - PSIW3	-3.52765	-1.22473	-4.305	20	.000
Pair 11	PSIR1 - PSIW4	-4.49064	-2.25481	-6.274	21	.000
Pair 12	PSIR1 - PSIR2	.46644	2.09145	3.307	18	.004
Pair 13	PSIW3 - PSIW4	-2.08131	-1.07069	-6.437	24	.000
Pair 14	PSIW3 - PSIR2	2.25383	3.93564	7.732	18	.000
Pair 15	PSIW4 - PSIR2	3.72798	5.09020	13.462	21	.000

General Linear Model

Within-Subjects
Factors

Measure: MEASURE_1

time	Dependent Variable
1	SISbsln
2	SISW1
3	SISW2
4	SISR1
5	SISW3
6	SISW4
7	SISR2

Between-Subjects
Factors

	N
EXPGRP 1	8
2	9

Descriptive Statistics

EXPGRP		Mean	Std. Deviation	N
SISbsln	1	27.63	12.106	8
	2	31.67	13.314	9
	Total	29.76	12.533	17
SISW1	1	27.8750	18.05102	8
	2	31.1111	14.72620	9
	Total	29.5882	15.92976	17
SISW2	1	19.7500	15.00238	8
	2	25.0000	11.66190	9
	Total	22.5294	13.18198	17
SISR1	1	20.3750	11.71004	8
	2	20.7778	9.83333	9
	Total	20.5882	10.41068	17
SISW3	1	16.7500	10.72714	8
	2	25.6667	9.36750	9
	Total	21.4706	10.73614	17
SISW4	1	17.5000	12.45564	8
	2	27.4444	12.45102	9
	Total	22.7647	13.09833	17
SISR2	1	15.8750	14.07569	8
	2	24.8889	6.71648	9
	Total	20.6471	11.43428	17

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.082	31.914	20	.050

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

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

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Epsilon ^a		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.600	.865	.167

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

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

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

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	1679.569	6	279.928	6.681
	Greenhouse-Geisser	1679.569	3.597	466.876	6.681
	Huynh-Feldt	1679.569	5.188	323.739	6.681
	Lower-bound	1679.569	1.000	1679.569	6.681
time * EXPGRP	Sphericity Assumed	323.199	6	53.866	1.286
	Greenhouse-Geisser	323.199	3.597	89.841	1.286
	Huynh-Feldt	323.199	5.188	62.297	1.286
	Lower-bound	323.199	1.000	323.199	1.286
Error(time)	Sphericity Assumed	3770.952	90	41.899	
	Greenhouse-Geisser	3770.952	53.962	69.882	
	Huynh-Feldt	3770.952	77.821	48.457	
	Lower-bound	3770.952	15.000	251.397	

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^a
time	Sphericity Assumed	.000	.308	40.086	.999
	Greenhouse-Geisser	.000	.308	24.034	.981
	Huynh-Feldt	.000	.308	34.661	.997
	Lower-bound	.021	.308	6.681	.676
time * EXPGRP	Sphericity Assumed	.272	.079	7.714	.481
	Greenhouse-Geisser	.288	.079	4.625	.355
	Huynh-Feldt	.278	.079	6.670	.441
	Lower-bound	.275	.079	1.286	.186

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	66812.964	1	66812.964	79.118	.000	.841
EXPGRP	1007.451	1	1007.451	1.193	.292	.074
Error	12667.103	15	844.474			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Noncent. Parameter	Observed Power ^a
Intercept	79.118	1.000
EXPGRP	1.193	.176

a. Computed using alpha = .05

Profile Plots

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SISbsln	32.03	33	12.071	2.101
	SISW1	30.1212	33	12.93918	2.25242
Pair 2	SISbsln	31.79	34	11.967	2.052
	SISW2	24.0882	34	11.43458	1.96101
Pair 3	SISbsln	31.79	34	11.967	2.052
	SISR1	23.0588	34	9.37741	1.60821
Pair 4	SISbsln	30.62	29	12.137	2.254
	SISW3	23.3103	29	9.66992	1.79566
Pair 5	SISbsln	31.00	32	11.857	2.096
	SISW4	22.5938	32	11.03911	1.95146
Pair 6	SISbsln	30.90	30	11.938	2.180
	SISR2	22.2667	30	10.33886	1.88761
Pair 7	SISW1	30.1212	33	12.93918	2.25242
	SISW2	24.4545	33	11.40748	1.98579
Pair 8	SISW1	30.1212	33	12.93918	2.25242
	SISR1	23.2424	33	9.46054	1.64687
Pair 9	SISW1	29.3214	28	13.83247	2.61409
	SISW3	23.6786	28	9.63809	1.82143
Pair 10	SISW1	29.6452	31	13.21753	2.37394
	SISW4	22.9355	31	11.04818	1.98431
Pair 11	SISW1	30.1379	29	13.34628	2.47834
	SISR2	22.6552	29	10.29659	1.91203
Pair 12	SISW2	24.0882	34	11.43458	1.96101
	SISR1	23.0588	34	9.37741	1.60821
Pair 13	SISW2	23.3793	29	12.18434	2.26258
	SISW3	23.3103	29	9.66992	1.79566
Pair 14	SISW2	23.6563	32	11.64698	2.05892
	SISW4	22.5938	32	11.03911	1.95146
Pair 15	SISW2	23.7333	30	11.87560	2.16818
	SISR2	22.2667	30	10.33886	1.88761
Pair 16	SISR1	22.1724	29	9.74705	1.80998
	SISW3	23.3103	29	9.66992	1.79566
Pair 17	SISR1	22.7188	32	9.56888	1.69156
	SISW4	22.5938	32	11.03911	1.95146
Pair 18	SISR1	22.9333	30	9.65592	1.76292
	SISR2	22.2667	30	10.33886	1.88761
Pair 19	SISW3	23.3103	29	9.66992	1.79566
	SISW4	22.3793	29	11.36226	2.10992

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 20	SISW3	23.2857	28	9.84644	1.86080
	SISR2	21.8214	28	10.56919	1.99739
Pair 21	SISW4	22.8667	30	11.29764	2.06266
	SISR2	22.2667	30	10.33886	1.88761

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	SISbsln & SISW1	33	.604	.000
Pair 2	SISbsln & SISW2	34	.810	.000
Pair 3	SISbsln & SISR1	34	.812	.000
Pair 4	SISbsln & SISW3	29	.697	.000
Pair 5	SISbsln & SISW4	32	.658	.000
Pair 6	SISbsln & SISR2	30	.715	.000
Pair 7	SISW1 & SISW2	33	.703	.000
Pair 8	SISW1 & SISR1	33	.668	.000
Pair 9	SISW1 & SISW3	28	.601	.001
Pair 10	SISW1 & SISW4	31	.599	.000
Pair 11	SISW1 & SISR2	29	.607	.000
Pair 12	SISW2 & SISR1	34	.847	.000
Pair 13	SISW2 & SISW3	29	.830	.000
Pair 14	SISW2 & SISW4	32	.740	.000
Pair 15	SISW2 & SISR2	30	.746	.000
Pair 16	SISR1 & SISW3	29	.814	.000
Pair 17	SISR1 & SISW4	32	.703	.000
Pair 18	SISR1 & SISR2	30	.741	.000
Pair 19	SISW3 & SISW4	29	.766	.000
Pair 20	SISW3 & SISR2	28	.769	.000
Pair 21	SISW4 & SISR2	30	.657	.000

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	SIbsIn - SiSW1	1.90909	11.15617	1.94204
Pair 2	SIbsIn - SiSW2	7.70588	7.23011	1.23995
Pair 3	SIbsIn - SiSR1	8.73529	6.98617	1.19812
Pair 4	SIbsIn - SiSW3	7.31034	8.78759	1.63181
Pair 5	SIbsIn - SiSW4	8.40625	9.49315	1.67817
Pair 6	SIbsIn - SiSR2	8.63333	8.54394	1.55990
Pair 7	SiSW1 - SiSW2	5.66667	9.49561	1.65297
Pair 8	SiSW1 - SiSR1	6.87879	9.66229	1.68199
Pair 9	SiSW1 - SiSW3	5.64286	11.13292	2.10392
Pair 10	SiSW1 - SiSW4	6.70968	11.03387	1.98174
Pair 11	SiSW1 - SiSR2	7.48276	10.82530	2.01021
Pair 12	SiSW2 - SiSR1	1.02941	6.08767	1.04403
Pair 13	SiSW2 - SiSW3	.06897	6.81349	1.26523
Pair 14	SiSW2 - SiSW4	1.06250	8.19495	1.44868
Pair 15	SiSW2 - SiSR2	1.46667	8.04613	1.46902
Pair 16	SiSR1 - SiSW3	-1.13793	5.92648	1.10052
Pair 17	SiSR1 - SiSW4	.12500	8.05525	1.42398
Pair 18	SiSR1 - SiSR2	.66667	7.21748	1.31772
Pair 19	SiSW3 - SiSW4	.93103	7.36755	1.36812
Pair 20	SiSW3 - SiSR2	1.46429	6.97340	1.31785
Pair 21	SiSW4 - SiSR2	.60000	9.00038	1.64324

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	SISbsln - SISW1	-2.04672	5.86490	.983	32	.333
Pair 2	SISbsln - SISW2	5.18318	10.22859	6.215	33	.000
Pair 3	SISbsln - SISR1	6.29770	11.17288	7.291	33	.000
Pair 4	SISbsln - SISW3	3.96773	10.65296	4.480	28	.000
Pair 5	SISbsln - SISW4	4.98360	11.82890	5.009	31	.000
Pair 6	SISbsln - SISR2	5.44298	11.82369	5.535	29	.000
Pair 7	SISW1 - SISW2	2.29967	9.03366	3.428	32	.002
Pair 8	SISW1 - SISR1	3.45269	10.30489	4.090	32	.000
Pair 9	SISW1 - SISW3	1.32596	9.95975	2.682	27	.012
Pair 10	SISW1 - SISW4	2.66242	10.75693	3.386	30	.002
Pair 11	SISW1 - SISR2	3.36503	11.60048	3.722	28	.001
Pair 12	SISW2 - SISR1	-1.09468	3.15350	.986	33	.331
Pair 13	SISW2 - SISW3	-2.52275	2.66068	.055	28	.957
Pair 14	SISW2 - SISW4	-1.89210	4.01710	.733	31	.469
Pair 15	SISW2 - SISR2	-1.53781	4.47114	.998	29	.326
Pair 16	SISR1 - SISW3	-3.39224	1.11638	-1.034	28	.310
Pair 17	SISR1 - SISW4	-2.77923	3.02923	.088	31	.931
Pair 18	SISR1 - SISR2	-2.02838	3.36172	.506	29	.617
Pair 19	SISW3 - SISW4	-1.87143	3.73350	.681	28	.502
Pair 20	SISW3 - SISR2	-1.23972	4.16829	1.111	27	.276
Pair 21	SISW4 - SISR2	-2.76080	3.96080	.365	29	.718

General Linear Model

Within-Subjects
Factors

Measure: MEASURE_1

time	Dependent Variable
1	PTSbsln
2	PTSW1
3	PTSW2
4	PTSR1
5	PTSW3
6	PTSW4
7	PTSR2

Between-Subjects
Factors

	N
EXPGRP 1	9
2	7

Descriptive Statistics

EXPGRP	Mean	Std. Deviation	N
PTSbsln 1	4.67	.707	9
2	5.00	.577	7
Total	4.81	.655	16
PTSW1 1	6.1111	.60093	9
2	6.0000	.57735	7
Total	6.0625	.57373	16
PTSW2 1	6.8889	.60093	9
2	6.4286	1.13389	7
Total	6.6875	.87321	16
PTSR1 1	5.0000	1.11803	9
2	4.1429	1.06904	7
Total	4.6250	1.14746	16
PTSW3 1	6.5556	.72648	9
2	6.2857	.95119	7
Total	6.4375	.81394	16
PTSW4 1	7.0000	.70711	9
2	6.5714	.78680	7
Total	6.8125	.75000	16
PTSR2 1	4.7778	.66667	9
2	4.0000	.81650	7
Total	4.4375	.81394	16

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.240	16.804	20	.680

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

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

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Epsilon ^a		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.751	1.000	.167

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

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

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

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	102.100	6	17.017	37.733
	Greenhouse-Geisser	102.100	4.506	22.659	37.733
	Huynh-Feldt	102.100	6.000	17.017	37.733
	Lower-bound	102.100	1.000	102.100	37.733
time * EXPGRP	Sphericity Assumed	3.886	6	.648	1.436
	Greenhouse-Geisser	3.886	4.506	.862	1.436
	Huynh-Feldt	3.886	6.000	.648	1.436
	Lower-bound	3.886	1.000	3.886	1.436
Error(time)	Sphericity Assumed	37.882	84	.451	
	Greenhouse-Geisser	37.882	63.084	.601	
	Huynh-Feldt	37.882	84.000	.451	
	Lower-bound	37.882	14.000	2.706	

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^a
time	Sphericity Assumed	.000	.729	226.397	1.000
	Greenhouse-Geisser	.000	.729	170.024	1.000
	Huynh-Feldt	.000	.729	226.397	1.000
	Lower-bound	.000	.729	37.733	1.000
time * EXPGRP	Sphericity Assumed	.211	.093	8.616	.531
	Greenhouse-Geisser	.228	.093	6.471	.448
	Huynh-Feldt	.211	.093	8.616	.531
	Lower-bound	.251	.093	1.436	.201

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3548.755	1	3548.755	1956.950	.000	.993
EXPGRP	3.719	1	3.719	2.051	.174	.128
Error	25.388	14	1.813			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Noncent. Parameter	Observed Power ^a
Intercept	1956.950	1.000
EXPGRP	2.051	.266

a. Computed using alpha = .05

Profile Plots

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PTSbsln	4.61	38	.790	.128
	PTSW1	6.1316	38	.57756	.09369
Pair 2	PTSbsln	4.72	36	.615	.102
	PTSW2	6.8611	36	.76168	.12695
Pair 3	PTSbsln	4.61	38	.790	.128
	PTSR1	4.6053	38	1.00107	.16239
Pair 4	PTSbsln	4.62	34	.817	.140
	PTSW3	6.2941	34	.83591	.14336
Pair 5	PTSbsln	4.63	35	.808	.136
	PTSW4	6.7714	35	.68966	.11657
Pair 6	PTSbsln	4.61	33	.827	.144
	PTSR2	4.0303	33	.95147	.16563
Pair 7	PTSW1	6.1667	36	.56061	.09344
	PTSW2	6.8611	36	.76168	.12695
Pair 8	PTSW1	6.1316	38	.57756	.09369
	PTSR1	4.6053	38	1.00107	.16239
Pair 9	PTSW1	6.1176	34	.59108	.10137
	PTSW3	6.2941	34	.83591	.14336
Pair 10	PTSW1	6.1143	35	.58266	.09849
	PTSW4	6.7714	35	.68966	.11657
Pair 11	PTSW1	6.0909	33	.57899	.10079
	PTSR2	4.0303	33	.95147	.16563
Pair 12	PTSW2	6.8611	36	.76168	.12695
	PTSR1	4.6389	36	1.01848	.16975
Pair 13	PTSW2	6.8125	32	.78030	.13794
	PTSW3	6.3438	32	.82733	.14625
Pair 14	PTSW2	6.8182	33	.76871	.13381
	PTSW4	6.7879	33	.69631	.12121
Pair 15	PTSW2	6.8065	31	.74919	.13456
	PTSR2	4.0000	31	.96609	.17352
Pair 16	PTSR1	4.5882	34	1.04787	.17971
	PTSW3	6.2941	34	.83591	.14336
Pair 17	PTSR1	4.5429	35	1.01003	.17073
	PTSW4	6.7714	35	.68966	.11657
Pair 18	PTSR1	4.5758	33	1.03169	.17959
	PTSR2	4.0303	33	.95147	.16563
Pair 19	PTSW3	6.2727	33	.83937	.14612
	PTSW4	6.8182	33	.68258	.11882

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 20	PTSW3	6.2581	31	.81518	.14641
	PTSR2	4.0645	31	.96386	.17311
Pair 21	PTSW4	6.7188	32	.68318	.12077
	PTSR2	4.0313	32	.96668	.17089

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PTSbsln & PTSW1	38	.532	.001
Pair 2	PTSbsln & PTSW2	36	.159	.353
Pair 3	PTSbsln & PTSR1	38	.139	.404
Pair 4	PTSbsln & PTSW3	34	.303	.082
Pair 5	PTSbsln & PTSW4	35	.318	.062
Pair 6	PTSbsln & PTSR2	33	-.104	.566
Pair 7	PTSW1 & PTSW2	36	.524	.001
Pair 8	PTSW1 & PTSR1	38	.279	.090
Pair 9	PTSW1 & PTSW3	34	.541	.001
Pair 10	PTSW1 & PTSW4	35	.286	.095
Pair 11	PTSW1 & PTSR2	33	-.175	.329
Pair 12	PTSW2 & PTSR1	36	.375	.024
Pair 13	PTSW2 & PTSW3	32	.303	.092
Pair 14	PTSW2 & PTSW4	33	.276	.120
Pair 15	PTSW2 & PTSR2	31	-.046	.806
Pair 16	PTSR1 & PTSW3	34	.454	.007
Pair 17	PTSR1 & PTSW4	35	.394	.019
Pair 18	PTSR1 & PTSR2	33	.141	.434
Pair 19	PTSW3 & PTSW4	33	.417	.016
Pair 20	PTSW3 & PTSR2	31	.275	.134
Pair 21	PTSW4 & PTSR2	32	.258	.154

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PTSbsln - PTSW1	-1.52632	.68721	.11148
Pair 2	PTSbsln - PTSW2	-2.13889	.89929	.14988
Pair 3	PTSbsln - PTSR1	.00000	1.18550	.19231
Pair 4	PTSbsln - PTSW3	-1.67647	.97610	.16740
Pair 5	PTSbsln - PTSW4	-2.14286	.87927	.14862
Pair 6	PTSbsln - PTSR2	.57576	1.32359	.23041
Pair 7	PTSW1 - PTSW2	-.69444	.66845	.11141
Pair 8	PTSW1 - PTSR1	1.52632	1.00638	.16326
Pair 9	PTSW1 - PTSW3	-.17647	.71650	.12288
Pair 10	PTSW1 - PTSW4	-.65714	.76477	.12927
Pair 11	PTSW1 - PTSR2	2.06061	1.19738	.20844
Pair 12	PTSW2 - PTSR1	2.22222	1.01731	.16955
Pair 13	PTSW2 - PTSW3	.46875	.94985	.16791
Pair 14	PTSW2 - PTSW4	.03030	.88335	.15377
Pair 15	PTSW2 - PTSR2	2.80645	1.24952	.22442
Pair 16	PTSR1 - PTSW3	-1.70588	1.00089	.17165
Pair 17	PTSR1 - PTSW4	-2.22857	.97274	.16442
Pair 18	PTSR1 - PTSR2	.54545	1.30122	.22651
Pair 19	PTSW3 - PTSW4	-.54545	.83258	.14493
Pair 20	PTSW3 - PTSR2	2.19355	1.07763	.19355
Pair 21	PTSW4 - PTSR2	2.68750	1.02980	.18204

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	PTSbsln - PTSW1	-1.75220	-1.30043	-13.691	37	.000
Pair 2	PTSbsln - PTSW2	-2.44317	-1.83461	-14.270	35	.000
Pair 3	PTSbsln - PTSR1	-.38966	.38966	.000	37	1.000
Pair 4	PTSbsln - PTSW3	-2.01705	-1.33589	-10.015	33	.000
Pair 5	PTSbsln - PTSW4	-2.44490	-1.84082	-14.418	34	.000
Pair 6	PTSbsln - PTSR2	.10643	1.04508	2.499	32	.018
Pair 7	PTSW1 - PTSW2	-.92062	-.46827	-6.233	35	.000
Pair 8	PTSW1 - PTSR1	1.19553	1.85710	9.349	37	.000
Pair 9	PTSW1 - PTSW3	-.42647	.07353	-1.436	33	.160
Pair 10	PTSW1 - PTSW4	-.91985	-.39443	-5.083	34	.000
Pair 11	PTSW1 - PTSR2	1.63603	2.48518	9.886	32	.000
Pair 12	PTSW2 - PTSR1	1.87801	2.56643	13.106	35	.000
Pair 13	PTSW2 - PTSW3	.12629	.81121	2.792	31	.009
Pair 14	PTSW2 - PTSW4	-.28292	.34352	.197	32	.845
Pair 15	PTSW2 - PTSR2	2.34813	3.26478	12.505	30	.000
Pair 16	PTSR1 - PTSW3	-2.05511	-1.35666	-9.938	33	.000
Pair 17	PTSR1 - PTSW4	-2.56272	-1.89442	-13.554	34	.000
Pair 18	PTSR1 - PTSR2	.08406	1.00685	2.408	32	.022
Pair 19	PTSW3 - PTSW4	-.84067	-.25024	-3.764	32	.001
Pair 20	PTSW3 - PTSR2	1.79827	2.58883	11.333	30	.000
Pair 21	PTSW4 - PTSR2	2.31622	3.05878	14.763	31	.000

General Linear Model

Within-Subjects
Factors

Measure: MEASURE_1

time	Dependent Variable
1	RPEbsln
2	RPEW1
3	RPEW2
4	RPER1
5	RPEW3
6	RPEW4
7	RPER2

Between-Subjects
Factors

	N
EXPGRP 1	12
2	9

Descriptive Statistics

EXPGRP	Mean	Std. Deviation	N
RPEbsln 1	7.75	2.179	12
2	7.33	1.323	9
Total	7.57	1.832	21
RPEW1 1	14.9167	1.37895	12
2	14.2222	2.16667	9
Total	14.6190	1.74574	21
RPEW2 1	17.4167	1.83196	12
2	16.8889	1.45297	9
Total	17.1905	1.66190	21
RPER1 1	10.1667	2.20880	12
2	9.5556	2.74368	9
Total	9.9048	2.40634	21
RPEW3 1	14.9167	5.05350	12
2	14.8889	2.08833	9
Total	14.9048	3.97372	21
RPEW4 1	15.9167	5.23030	12
2	16.0000	1.00000	9
Total	15.9524	3.93035	21
RPER2 1	9.4167	3.52803	12
2	8.6667	2.00000	9
Total	9.0952	2.93095	21

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.010	78.094	20	.000

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

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

Mauchly's Test of Sphericity^b

Measure: MEASURE_1

Within Subjects Effect	Epsilon ^a		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.360	.430	.167

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

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

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

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
time	Sphericity Assumed	1786.418	6	297.736	48.556
	Greenhouse-Geisser	1786.418	2.162	826.383	48.556
	Huynh-Feldt	1786.418	2.577	693.150	48.556
	Lower-bound	1786.418	1.000	1786.418	48.556
time * EXPGRP	Sphericity Assumed	3.289	6	.548	.089
	Greenhouse-Geisser	3.289	2.162	1.522	.089
	Huynh-Feldt	3.289	2.577	1.276	.089
	Lower-bound	3.289	1.000	3.289	.089
Error(time)	Sphericity Assumed	699.024	114	6.132	
	Greenhouse-Geisser	699.024	41.073	17.019	
	Huynh-Feldt	699.024	48.968	14.275	
	Lower-bound	699.024	19.000	36.791	

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^a
time	Sphericity Assumed	.000	.719	291.337	1.000
	Greenhouse-Geisser	.000	.719	104.965	1.000
	Huynh-Feldt	.000	.719	125.141	1.000
	Lower-bound	.000	.719	48.556	1.000
time * EXPGRP	Sphericity Assumed	.997	.005	.536	.071
	Greenhouse-Geisser	.927	.005	.193	.063
	Huynh-Feldt	.950	.005	.230	.064
	Lower-bound	.768	.005	.089	.059

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	23292.574	1	23292.574	1143.469	.000	.984
EXPGRP	6.370	1	6.370	.313	.583	.016
Error	387.032	19	20.370			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Noncent. Parameter	Observed Power ^a
Intercept	1143.469	1.000
EXPGRP	.313	.083

a. Computed using alpha = .05

Profile Plots

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	RPEbsln	7.53	38	1.782	.289
	RPEW1	14.7632	38	2.03263	.32974
Pair 2	RPEbsln	7.57	37	1.788	.294
	RPEW2	17.0811	37	2.01905	.33193
Pair 3	RPEbsln	7.54	37	1.804	.297
	RPER1	9.4054	37	2.91032	.47845
Pair 4	RPEbsln	7.36	36	1.641	.274
	RPEW3	15.0556	36	3.26842	.54474
Pair 5	RPEbsln	7.53	36	1.797	.299
	RPEW4	16.3056	36	3.35363	.55894
Pair 6	RPEbsln	7.51	35	1.837	.311
	RPER2	8.8286	35	2.52617	.42700
Pair 7	RPEW1	14.8649	37	1.96019	.32225
	RPEW2	17.0811	37	2.01905	.33193
Pair 8	RPEW1	14.7027	37	2.02574	.33303
	RPER1	9.4054	37	2.91032	.47845
Pair 9	RPEW1	14.6944	36	2.05384	.34231
	RPEW3	15.0556	36	3.26842	.54474
Pair 10	RPEW1	14.7778	36	2.00159	.33360
	RPEW4	16.3056	36	3.35363	.55894
Pair 11	RPEW1	14.6286	35	2.04487	.34565
	RPER2	8.8286	35	2.52617	.42700
Pair 12	RPEW2	17.0833	36	2.04765	.34127
	RPER1	9.4167	36	2.95079	.49180
Pair 13	RPEW2	16.9714	35	2.00713	.33927
	RPEW3	15.1143	35	3.29680	.55726
Pair 14	RPEW2	17.0571	35	1.98439	.33542
	RPEW4	16.2000	35	3.34136	.56479
Pair 15	RPEW2	17.0294	34	2.03731	.34940
	RPER2	8.7647	34	2.53531	.43480
Pair 16	RPER1	9.4571	35	2.96393	.50100
	RPEW3	15.0000	35	3.29884	.55761
Pair 17	RPER1	9.3714	35	2.90117	.49039
	RPEW4	16.2286	35	3.37016	.56966
Pair 18	RPER1	9.5143	35	2.95427	.49936
	RPER2	8.8286	35	2.52617	.42700
Pair 19	RPEW3	15.0000	35	3.29884	.55761
	RPEW4	16.4000	35	3.35366	.56687

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 20	RPEW3	15.0294	34	3.34379	.57346
	RPER2	8.8235	34	2.56398	.43972
Pair 21	RPEW4	16.1471	34	3.38564	.58063
	RPER2	8.7647	34	2.53531	.43480

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	RPEbsln & RPEW1	38	.326	.046
Pair 2	RPEbsln & RPEW2	37	.472	.003
Pair 3	RPEbsln & RPER1	37	.163	.334
Pair 4	RPEbsln & RPEW3	36	-.180	.295
Pair 5	RPEbsln & RPEW4	36	-.236	.166
Pair 6	RPEbsln & RPER2	35	-.120	.493
Pair 7	RPEW1 & RPEW2	37	.445	.006
Pair 8	RPEW1 & RPER1	37	-.069	.687
Pair 9	RPEW1 & RPEW3	36	.122	.479
Pair 10	RPEW1 & RPEW4	36	.044	.797
Pair 11	RPEW1 & RPER2	35	.004	.980
Pair 12	RPEW2 & RPER1	36	.093	.588
Pair 13	RPEW2 & RPEW3	35	.192	.270
Pair 14	RPEW2 & RPEW4	35	.273	.112
Pair 15	RPEW2 & RPER2	34	.166	.349
Pair 16	RPER1 & RPEW3	35	.027	.877
Pair 17	RPER1 & RPEW4	35	-.078	.656
Pair 18	RPER1 & RPER2	35	.422	.012
Pair 19	RPEW3 & RPEW4	35	.787	.000
Pair 20	RPEW3 & RPER2	34	.598	.000
Pair 21	RPEW4 & RPER2	34	.724	.000

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	RPEbsln - RPEW1	-7.23684	2.22315	.36064
Pair 2	RPEbsln - RPEW2	-9.51351	1.96669	.32332
Pair 3	RPEbsln - RPER1	-1.86486	3.16370	.52011
Pair 4	RPEbsln - RPEW3	-7.69444	3.91203	.65200
Pair 5	RPEbsln - RPEW4	-8.77778	4.16181	.69363
Pair 6	RPEbsln - RPER2	-1.31429	3.29680	.55726
Pair 7	RPEW1 - RPEW2	-2.21622	2.09676	.34470
Pair 8	RPEW1 - RPER1	5.29730	3.65806	.60138
Pair 9	RPEW1 - RPEW3	-.36111	3.64223	.60704
Pair 10	RPEW1 - RPEW4	-1.52778	3.82836	.63806
Pair 11	RPEW1 - RPER2	5.80000	3.24309	.54818
Pair 12	RPEW2 - RPER1	7.66667	3.43095	.57183
Pair 13	RPEW2 - RPEW3	1.85714	3.51587	.59429
Pair 14	RPEW2 - RPEW4	.85714	3.38807	.57269
Pair 15	RPEW2 - RPER2	8.26471	2.97778	.51069
Pair 16	RPER1 - RPEW3	-5.54286	4.37468	.73946
Pair 17	RPER1 - RPEW4	-6.85714	4.61547	.78016
Pair 18	RPER1 - RPER2	.68571	2.96818	.50171
Pair 19	RPEW3 - RPEW4	-1.40000	2.17201	.36714
Pair 20	RPEW3 - RPER2	6.20588	2.73894	.46972
Pair 21	RPEW4 - RPER2	7.38235	2.33569	.40057

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	RPEbsln - RPEW1	-7.96757	-6.50611	-20.067	37	.000
Pair 2	RPEbsln - RPEW2	-10.16924	-8.85779	-29.424	36	.000
Pair 3	RPEbsln - RPER1	-2.91970	-.81003	-3.586	36	.001
Pair 4	RPEbsln - RPEW3	-9.01808	-6.37080	-11.801	35	.000
Pair 5	RPEbsln - RPEW4	-10.18593	-7.36962	-12.655	35	.000
Pair 6	RPEbsln - RPER2	-2.44678	-.18179	-2.358	34	.024
Pair 7	RPEW1 - RPEW2	-2.91531	-1.51712	-6.429	36	.000
Pair 8	RPEW1 - RPER1	4.07764	6.51695	8.809	36	.000
Pair 9	RPEW1 - RPEW3	-1.59347	.87124	-.595	35	.556
Pair 10	RPEW1 - RPEW4	-2.82311	-.23245	-2.394	35	.022
Pair 11	RPEW1 - RPER2	4.68596	6.91404	10.580	34	.000
Pair 12	RPEW2 - RPER1	6.50580	8.82753	13.407	35	.000
Pair 13	RPEW2 - RPEW3	.64940	3.06489	3.125	34	.004
Pair 14	RPEW2 - RPEW4	-.30670	2.02098	1.497	34	.144
Pair 15	RPEW2 - RPER2	7.22571	9.30370	16.184	33	.000
Pair 16	RPER1 - RPEW3	-7.04561	-4.04010	-7.496	34	.000
Pair 17	RPER1 - RPEW4	-8.44261	-5.27168	-8.789	34	.000
Pair 18	RPER1 - RPER2	-.33389	1.70532	1.367	34	.181
Pair 19	RPEW3 - RPEW4	-2.14611	-.65389	-3.813	34	.001
Pair 20	RPEW3 - RPER2	5.25022	7.16154	13.212	33	.000
Pair 21	RPEW4 - RPER2	6.56739	8.19731	18.430	33	.000

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
GIW1T15	38.3231	.41897	26
GIW2T15	39.1408	.46662	24
GIR1T15	38.5917	.62060	23
GIW3T15	38.4959	.38483	22
GIW4T15	38.8730	.38097	20
GIR2T15	38.4435	.42409	20
PTSW1	6.0769	.56022	26
PTSW2	6.8333	.81650	24
PTSR1	4.6538	1.01754	26
PTSW3	6.4091	.85407	22
PTSW4	6.7826	.73587	23
PTSR2	4.3333	.79582	21

Correlations

		GIW1T15	GIW2T15	GIR1T15	GIW3T15	GIW4T15
GIW1T15	Pearson Correlation	1	.750	.200	.189	.328
	Sig. (2-tailed)		.000	.360	.399	.158
	N	26	24	23	22	20
GIW2T15	Pearson Correlation	.750	1	.568	.205	.433
	Sig. (2-tailed)	.000		.005	.372	.064
	N	24	24	23	21	19
GIR1T15	Pearson Correlation	.200	.568	1	.256	.172
	Sig. (2-tailed)	.360	.005		.263	.482
	N	23	23	23	21	19
GIW3T15	Pearson Correlation	.189	.205	.256	1	.512
	Sig. (2-tailed)	.399	.372	.263		.021
	N	22	21	21	22	20
GIW4T15	Pearson Correlation	.328	.433	.172	.512	1
	Sig. (2-tailed)	.158	.064	.482	.021	
	N	20	19	19	20	20
GIR2T15	Pearson Correlation	.213	.392	.300	.555	.780
	Sig. (2-tailed)	.367	.097	.212	.011	.000
	N	20	19	19	20	20
PTSW1	Pearson Correlation	.178	.151	.146	.242	.038
	Sig. (2-tailed)	.385	.480	.507	.278	.873
	N	26	24	23	22	20

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

		GIR2T15	PTSW1	PTSW2	PTSR1	PTSW3
GIW1T15	Pearson Correlation	.213	.178	.134	.181	.253
	Sig. (2-tailed)	.367	.385	.533	.377	.256
	N	20	26	24	26	22
GIW2T15	Pearson Correlation	.392	.151	.062	.063	.130
	Sig. (2-tailed)	.097	.480	.782	.771	.585
	N	19	24	22	24	20
GIR1T15	Pearson Correlation	.300	.146	.206	.161	.242
	Sig. (2-tailed)	.212	.507	.370	.462	.304
	N	19	23	21	23	20
GIW3T15	Pearson Correlation	.555	.242	.122	.389	.581
	Sig. (2-tailed)	.011	.278	.607	.074	.006
	N	20	22	20	22	21
GIW4T15	Pearson Correlation	.780	.038	-.006	-.027	.329
	Sig. (2-tailed)	.000	.873	.980	.909	.168
	N	20	20	18	20	19
GIR2T15	Pearson Correlation	1	.022	.120	.070	.313
	Sig. (2-tailed)		.927	.636	.769	.192
	N	20	20	18	20	19
PTSW1	Pearson Correlation	.022	1	.546	.329	.735
	Sig. (2-tailed)	.927		.006	.100	.000
	N	20	26	24	26	22

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

		PTSW4	PTSR2
GIW1T15	Pearson Correlation	-.172	-.364
	Sig. (2-tailed)	.432	.104
	N	23	21
GIW2T15	Pearson Correlation	-.390	-.283
	Sig. (2-tailed)	.080	.241
	N	21	19
GIR1T15	Pearson Correlation	-.181	.017
	Sig. (2-tailed)	.445	.945
	N	20	18
GIW3T15	Pearson Correlation	.240	.391
	Sig. (2-tailed)	.295	.098
	N	21	19
GIW4T15	Pearson Correlation	.118	.255
	Sig. (2-tailed)	.619	.324
	N	20	17
GIR2T15	Pearson Correlation	.078	.390
	Sig. (2-tailed)	.743	.122
	N	20	17
PTSW1	Pearson Correlation	.134	-.115
	Sig. (2-tailed)	.543	.621
	N	23	21

Correlations

		GIW1T15	GIW2T15	GIR1T15	GIW3T15	GIW4T15
PTSW2	Pearson Correlation	.134	.062	.206	.122	-.006
	Sig. (2-tailed)	.533	.782	.370	.607	.980
	N	24	22	21	20	18
PTSR1	Pearson Correlation	.181	.063	.161	.389	-.027
	Sig. (2-tailed)	.377	.771	.462	.074	.909
	N	26	24	23	22	20
PTSW3	Pearson Correlation	.253	.130	.242	.581	.329
	Sig. (2-tailed)	.256	.585	.304	.006	.168
	N	22	20	20	21	19
PTSW4	Pearson Correlation	-.172	-.390	-.181	.240	.118
	Sig. (2-tailed)	.432	.080	.445	.295	.619
	N	23	21	20	21	20
PTSR2	Pearson Correlation	-.364	-.283	.017	.391	.255
	Sig. (2-tailed)	.104	.241	.945	.098	.324
	N	21	19	18	19	17

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

		GIR2T15	PTSW1	PTSW2	PTSR1	PTSW3
PTSW2	Pearson Correlation	.120	.546	1	.349	.561
	Sig. (2-tailed)	.636	.006		.094	.010
	N	18	24	24	24	20
PTSR1	Pearson Correlation	.070	.329	.349	1	.473
	Sig. (2-tailed)	.769	.100	.094		.026
	N	20	26	24	26	22
PTSW3	Pearson Correlation	.313	.735	.561	.473	1
	Sig. (2-tailed)	.192	.000	.010	.026	
	N	19	22	20	22	22
PTSW4	Pearson Correlation	.078	.134	.164	.288	.409
	Sig. (2-tailed)	.743	.543	.476	.183	.066
	N	20	23	21	23	21
PTSR2	Pearson Correlation	.390	-.115	.133	.391	.266
	Sig. (2-tailed)	.122	.621	.588	.080	.272
	N	17	21	19	21	19

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

		PTSW4	PTSR2
PTSW2	Pearson Correlation	.164	.133
	Sig. (2-tailed)	.476	.588
	N	21	19
PTSR1	Pearson Correlation	.288	.391
	Sig. (2-tailed)	.183	.080
	N	23	21
PTSW3	Pearson Correlation	.409	.266
	Sig. (2-tailed)	.066	.272
	N	21	19
PTSW4	Pearson Correlation	1	.451
	Sig. (2-tailed)		.046
	N	23	20
PTSR2	Pearson Correlation	.451	1
	Sig. (2-tailed)	.046	
	N	20	21

*. Correlation is significant at the 0.05 level (2-tailed).

Oneway: day by session

Notes

Output Created	03-Feb-2011 12:46:41	
Comments		
Input	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	19
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax	ONEWAY wbgt BY Day.session /MISSING ANALYSIS.	
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.000

ANOVA

wbgt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	31.912	5	6.382	3.748	.025
Within Groups	22.140	13	1.703		
Total	54.052	18			

Oneway: first sessions

Notes

Output Created	03-Feb-2011 12:40:17	
Comments		
Input	Active Dataset	DataSet0
	Filter	Session = 1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax	ONEWAY wbgt BY Day /MISSING ANALYSIS.	
Resources	Processor Time	00:00:00.016
	Elapsed Time	00:00:00.015

ANOVA

wbgt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.826	2	1.913	2.152	.187
Within Groups	6.223	7	.889		
Total	10.049	9			

Oneway: second sessions

Notes

Output Created	03-Feb-2011 12:41:46	
Comments		
Input	Active Dataset	DataSet0
	Filter	Session = 2 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	9
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax	ONEWAY wbgt BY Day /MISSING ANALYSIS /POSTHOC=Tukey ALPHA(0.05).	
Resources	Processor Time	00:00:00.031
	Elapsed Time	00:00:00.031

ANOVA

wbgt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	28.083	2	14.042	5.293	.047
Within Groups	15.917	6	2.653		
Total	44.000	8			

Post Hoc Tests:

second session day 1 was different from second session day 3

Multiple Comparisons

wbgt
Tukey HSD

(I) Day	(J) Day	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-1.167	1.487	.725	-5.73	3.40
	3	-3.917*	1.244	.045	-7.73	-.10
2	1	1.167	1.487	.725	-3.40	5.73
	3	-2.750	1.411	.206	-7.08	1.58
3	1	3.917	1.244	.045	.10	7.73
	2	2.750	1.411	.206	-1.58	7.08

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

wbgt

Tukey HSD

Day	N	Subset for alpha = 0.05	
		1	N
1	3	25.33	
2	2	26.50	
3	4	29.25	
Sig.		.067	

Means for groups in homogeneous subsets are displayed.

Oneway: day 1, first to second session.

Notes

Output Created		03-Feb-2011 12:51:29
Comments		
Input	Active Dataset	DataSet0
	Filter	Day.session = 1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	6
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax		ONEWAY wbgt BY Session /MISSING ANALYSIS.
Resources	Processor Time	00:00:00.015
	Elapsed Time	00:00:00.015

ANOVA

wbgt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.602	1	1.602	4.348	.105
Within Groups	1.473	4	.368		
Total	3.075	5			

Oneway: day 2, first to second session

Notes

Output Created	03-Feb-2011 12:52:21	
Comments		
Input	Active Dataset	DataSet0
	Filter	Day.session = 2 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	5
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax	ONEWAY wbgt BY Session /MISSING ANALYSIS.	
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.016

ANOVA

wbgt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.633	1	1.633	.535	.518
Within Groups	9.167	3	3.056		
Total	10.800	4			

Oneway: day 3, first to second session

Notes

Output Created	03-Feb-2011 12:52:57	
Comments		
Input	Active Dataset	DataSet0
	Filter	Day.session = 3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	8
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax	ONEWAY wbgt BY Session /MISSING ANALYSIS.	
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.016

ANOVA

wbgt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.500	1	4.500	2.348	.176
Within Groups	11.500	6	1.917		
Total	16.000	7			

APPENDIX F: RECOMMENDATIONS

Improvements for methodology

- Use nude weights to improve accuracy of percent dehydration, sweat loss, and sweat rate calculations.
- Increase the number of participants to increase power. With the current number of participants we cannot be certain that the lack of statistically significant findings is actually due to no change or the small number of participants.
- Length of time of exchange periods and their procedures should be held more constant (ie, the time between the first/second and third/fourth drills should be kept constant, as well as what happened, such as kneeling, standing, consuming fluid, etc.)
- The number of times the Stroop test is administered should be reduced: before protocol, start and end of first rehab, start of second rehab, post protocol. While we found no statistical significance in head cooling's effect on cognitive function in this study, and we are looking at how it is affected at work at rest, we can remove the testing point in the exchange to help decrease and hold constant the amount of time at the exchange point and still have data regarding cognitive function at the end of two drills and the end of 15 minutes of rest.
- Test reaction time rather than ability to tolerate interference for cognitive function.
- Test every participant the same day, or not allow participants to know what day they will participate to reduce the amount of information regarding the study passed between firefighters

- Collect WBGT more often, outdoors and indoors, so that more descriptive data is available to create a better picture of the weather outdoors and the tower's environment.

Progression in the research field

- Effects of head cooling in firefighters when there is an external motivator, such as a live fire drill, goal oriented tasks, or an actual emergency call where the intensity of their work is not self-determined
- Relationship between perceived thermal sensation and gastrointestinal temperature when other means of accessory cooling are used
- Describe the hydration behaviors of firefighters via random urine sample collection (USG) with an accompanied survey on perceived knowledge of exertional heat illness and hydration behaviors versus actual knowledge
- Describe heart rates of firefighters during live fire drills and on a fire call, compared to maximum predicted heart rate
- Physiological and perceived effects of varying lengths of rehab periods on reduction of core body temperature
- Physiological and perceived effects of neck cooling during work and/or rehab
- Physiological and perceived effects of fan and water mist on face during rehab