Cold pressor test

 Cold Stress and the Cold Pressor Test Karri Haen Whitmer Maintaining homeostasis requires that the body continuously monitors its internal conditions. From body temperature to blood pressure to levels of certain nutrients, each physiological condition has a particular set point. A set point is the physiological value around which the normal range fluctuates. A normal range is the restricted set of values that is optimally healthful and stable. For example, the set point for normal human body temperature is approximately 37°C (98.6°F). Physiological parameters, such as body temperature and blood pressure, tend to fluctuate within a normal range a few degrees above and below that point. Control centers in the brain and other parts of the body monitor and react to deviations from homeostasis using negative feedback. Negative feedback is a mechanism that reverses a deviation from the set point. Therefore, negative feedback maintains body parameters within their normal range. The maintenance of homeostasis by negative feedback goes on throughout the body at all times. The human body regulates body temperature through a process called thermoregulation, in which the body can maintain its temperature within certain boundaries, even when the surrounding temperature is very different. The core temperature of the body remains steady at around 36.5–37.5 °C (or 97.7–99.5 °F). In the process of ATP production by cells throughout the body, approximately 60 percent of the energy produced is in the form of heat used to maintain body temperature. Thermoregulation is an example of negative feedback. The hypothalamus in the brain is the master switch that works as a thermostat to regulate the body's core temperature (Figure 1). If the temperature is too high, the hypothalamus can initiate several processes to lower it. These include increasing the circulation of the blood to the surface of the body to allow for the dissipation of heat through the skin and initiation of sweating to allow evaporation of water on the skin to cool its surface. Conversely, if the temperature falls below the set core temperature, the hypothalamus can initiate shivering to generate heat. The body uses more energy and generates more heat. In addition, thyroid hormone will stimulate more energy use and heat production by cells throughout the body. An environment is said to be thermoneutral when the body does not expend or release energy to maintain its core temperature. For a naked human, this is an ambient air temperature of around 84 °F. If the temperature is higher, for example, when wearing clothes, the body compensates with cooling mechanisms. The body loses heat through the mechanisms of heat exchange. Mechanisms of Heat Exchange When the environment is not thermoneutral, the body uses four mechanisms of heat exchange to maintain homeostasis: conduction, convection, radiation, and evaporation. Each of these mechanisms relies on the property of heat to flow from a higher concentration to a lower concentration; therefore, each of the mechanisms of heat exchange varies in rate according to the temperature and conditions of the environment. Conduction is the transfer of heat by two objects that are in direct contact with one another. It occurs when the skin comes in contact with a cold or warm object. For example, when holding a glass of ice water, the heat from your skin will warm the glass and in turn melt the ice. Alternatively, on a cold day, you might warm up by wrapping your cold hands around a hot mug of coffee. Only about 3 percent of the body's heat is lost through conduction. Convection is the transfer of heat to the air surrounding the skin. The warmed air rises away from the body and is replaced by cooler air that is subsequently heated. Convection can also occur in water. When the water temperature is lower than the body's temperature, the body loses heat by warming the water closest to the skin, which moves away to be replaced by cooler water. The convection currents created by the temperature changes continue to draw heat away from the body more quickly than the body can replace it, resulting in hypothermia. About 15 percent of the body's heat is lost through convection. Radiation is the transfer of heat via infrared waves. This occurs between any two objects when their temperatures differ. A radiator can warm a room via radiant heat. On a sunny day, the radiation from the sun warms the skin. The same principle works from the body to the environment. About 60 percent of the heat lost by the body is lost through radiation. Evaporation is the transfer of heat by the evaporation of water. Because it takes a great deal of energy for a water molecule to change from a liquid to a gas, evaporating water (in the form of sweat) takes with it a great deal of energy from the skin. However, the rate at which evaporation occurs depends on relative humidity—more sweat evaporates in lower humidity environments. Sweating is the primary means of cooling the body during exercise, whereas at rest, about 20 percent of the heat lost by the body occurs through evaporation. Homeostatic Response to Environmental Temperatures Humans have a temperature regulation feedback system that works by promoting either heat loss or heat gain. When the brain's temperature regulation center receives data from the sensors indicating that the body's temperature exceeds its normal range, it stimulates a cluster of brain cells referred to as the "heat-loss center." This stimulation has three major effects: Blood vessels in the skin begin to dilate allowing more blood from the body core to flow to the surface of the skin allowing the heat to radiate into the environment. As blood flow to the skin increases, sweat glands are activated to increase their output. As the sweat evaporates from the skin surface into the surrounding air, it takes heat with it. The depth of respiration increases, and a person may breathe through an open mouth instead of through the nasal passageways. This increases heat loss from the lungs. Figure 1. Hypothalamus Controls Thermoregulation. The hypothalamus controls thermoregulatory networks leading to an increase or decrease in the core body temperature. Original image OpenStax Anatomy and Physiology CC-by-4.0. Image edited by Aric Warner. In contrast, activation of the brain's heat-gain center by exposure to cold reduces blood flow to the skin, and blood returning from the limbs is diverted into a network of deep veins (Figure 2). This arrangement traps heat closer to the body core, restricts heat loss, and increases blood pressure. If heat loss is severe, the brain triggers an increase in random signals to skeletal muscles, causing them to contract and producing shivering. The muscle contractions of shivering release heat while using ATP. The brain also triggers the thyroid gland in the endocrine system to release thyroid hormone, which increases metabolic activity and heat production in cells throughout the body. Figure 2. Physiological response to acute cold exposure. During acute cold exposure, the sympathetic nervous system releases norepinephrine, which results in vasoconstriction, increased blood pressure, and increased heart rate. During acute exposure to cold conditions in the body: Activation of the sympathetic nervous system results in system-wide discharge of catecholamine (norepinephrine). Catecholamine causes systemic arteriolar constriction, increased heart rate and heart contractility. The heart works harder to push blood through the narrowed blood vessels. Constricted blood vessels in the extremities divert superficial blood flow to the body's core, thus, reducing the radiation or conduction of heat into the environment. Vasoconstriction increases the resistance to blood flow, and thus, increases blood pressure. Vasoconstriction leads to a weaker pulse (lower pulse amplitude) in the arteries of the skin, fingers and hand. The Cold Pressor Test Acute cold stress results in activation of the sympathetic nervous system and release of catecholamines (neurotransmitters). The release of neurotransmitter effects the cardiovascular system in a number of ways, including arterial constriction, transient tachycardia, and increased contractility of the heart. Together, these homeostatic changes result in what is called a pressor response, or an increase in blood pressure. The cold pressor test is commonly used in the clinical setting to evaluate the function of the sympathetic nervous system. In the cold pressor test, subjects immerse their hand or forearm in ice water, and their cardiovascular response is measured. In this laboratory, we will use the cold pressor test to evaluate changes in heart rate, pulse amplitude, and arterial oxygen saturation using a pulse oximeter. Pulse oximeters indirectly estimate the arterial oxygen saturation and report it as the oxygen saturation (SpO2) of the subject's arterial blood. SpO2 is reported as a percentage of oxygenated hemoglobin. Normal pulse oximetry values typically range from 97-100%. Figure 3. The pulse oximeter. Finger clamp pulse oximeters are used in the physiology laboratory. A light emitting diode rests on top of the finger, and a photodetector is located beneath the finger. Figure created by Cameron Miller CC-by-ND. Cold pressor response experiment: There are several hypotheses that could be testing In this laboratory. For example, we may test whether males and females have a different cold pressor response, or we may test whether the pressor response is the same in the submerged versus the non-submerged hand. After collecting the data, you will enter it into an excel file at the TA's bench for a class-wide or course-wide statistical analysis. In preparation for lab, can you write an IF/THEN hypothesis for testing the cold pressor response in men and women? Laboratory Methods In this lab you will conduct an experiment to test how acute cold exposure affects pulse amplitude, heart rate and hemoglobin-oxygen binding in men and women. You will be using a finger sensor called a pulse oximeter, which will measure the pulse as well as the peripheral arterial blood oxygenation (SpO2) in your finger. We will use iWorx with LabScribe to interpret pulse amplitude, heart rate and SpO2. Subjects should not wear nail polish, artificial nail coverings, hand or wrist jewelry during the experiment. Subjects must wear short sleeves or sleeves that can be rolled up above the elbow. All subjects will participate in either "Baseline/Condition 1" or "Baseline/Condition 2" but not both. All subjects will submerge their LEFT forearm in the experiments. Because the pulse oximeter works by detecting pulsation of blood vessels, subjects should sit quietly and motionless during the experiment. Other movements or vibrations could confound the pulse oximeter readings. Turn on the iWorx unit at the switch on the back of the box Log into your account and click the Folder icon in the lower left task bar Click "This PC" in the left side task bar Double click Biol 256L Course Materials P-Drive under "Network Locations" Double click the "Week4_ColdPressor" settings file Place the pulse oximeter on the middle finger of the left (condition 1) or right (condition 2) hand as shown in the figure below. You are now ready to start the experiment. Figure 4. How to wear the pulse oximeter sensor. IMPORTANT: This experiment requires half of the subjects to participate in Baseline/Condition 1 and half of the subjects to participate in Baseline/Condition 2. At your lab table, assign each student a condition before starting the experiment. CONTROL/CONDITION 1: Outfit the middle finger of the left hand with the pulse oximeter. Be prepared to submerge the left forearm in ice water at the one-minute mark. CONTROL/CONDITION 2: Outfit the middle finger of the right hand with the pulse oximeter. Be prepared to submerge the left forearm in ice water at the one-minute mark. PART I. Procedure Check the sensor: click on the red Record Click on the AutoScale button at the upper task bar. Your recording should look like the traces seen below in Figure 5. If the data does not appear as shown, slightly adjust the oximeter on the finger. Note the location of the Time in the upper right corner of the window (Fig. 5b). In the figure, the time reads "one minute and twenty-two seconds." You will keep track of the time of the data recording with this timer on the Labscribe window. Figure 5a. Example window showing correctly generated pulse, heart rate and SpO2 data. Figure 5b. Closeup view of the pulse window showing the time as Time1 (red box). When the signals being recorded are suitably displayed, stop the recording and open a new file. As the subject sits quietly (without moving) record baseline data for one minute. At exactly the one-minute mark, submerge the left forearm in the ice water. DO NOT put the hand with instrumentation in the water. Remain as still as possible! Record the data for at least an additional 35 seconds (you may record more). Stop recording. You may dry your arm off and warm it on a heating pad. You are done serving as subject after a single exposure to the ice bath. Save the data file to the computer. Put the subject's name and Week 4 in the title. PART II. Data Analysis This data analysis applies to both the baseline recording and to Condition 1 or 2. For baseline data, start at the very beginning of the recording and find the correct data by scrolling and using the timer on the main window. For the experimental data (condition 1 or 2), start data analysis at the 1.00 mark and scroll to 1.05 (five seconds), 1.10 (ten seconds), 1.20 (twenty seconds) and 1.30 (thirty seconds). To begin the data analysis: Calibrate the pulse channel. Set the time in the Display time window to 120 seconds and then click the Autoscale button in the channel window. Click on the P. Rate (Pulse) on the Heart Rate channel and select Setup Function When the window opens drag the blue lines so that the top line is just below the peaks of the ALL the pulse waves and the bottom line is slightly below the blue line (see figure below). It is very important that you see ALL of your data so that you can properly align the blue lines. Click OK. Image CC-by-4.0. Calibration image and text courtesy of Darren Mattone, Muskegon Community College. Analysis Use the Display Time icon to adjust the Display Time of the Main window to show approximately ten complete Pulse cycles on the Main window. Scroll through the recording to view exemplary pulse waves at these intervals during data recording: 5 seconds, 10 seconds, 20 seconds and 30 seconds Start at a pulse wave at around 5 seconds of data recording and click the double cursor icon and place the cursors as follows: To measure the pulse wave amplitude, place one cursor on the baseline that precedes the pulse wave and the second cursor on the peak of the pulse wave. The value for V2-V1 on the Pulse channel is this amplitude. Determine the pulse amplitude V2-V1 for the four pulse waves at the designated times and record the results in your lab report. To find the heart rate, select the one cursor icon and place the single cursor at the plateau of the of a heart rate trace on the Heart Rate channel. See the orange cursor in the picture below. Record the value in BPM on your lab report for heart rate data collected at approximately 5s, 10s, 20s and 30s. To find the SpO2, place cursor on the data at the 30 second mark of recording. Usually this line is completely flat. Record the SpO2 percent, shown on the O2 Saturation channel, in your lab report. After recording the data in your lab report, open a new file for the next student. Students may be asked to submit these data for statistical analysis: Note: please submit your sex (M or F) and age with your data. Baseline avg. heart rate Baseline avg. pulse wave amplitude Condition 1 avg. cold pressor heart rate Condition 1 avg. cold pressor pulse wave amplitude Condition 2 avg. cold pressor heart rate Condition 2 avg. cold pressor pulse wave amplitude Citations Please cite: Haen Whitmer, K.M. (2021). A Mixed Course-Based Research Approach to Human Physiology. Ames, IA: Iowa State University Digital Press. The Cold Pressor Test (CPT) is a well-established medical procedure used to assess an individual's pain tolerance and the body's cardiovascular responses to stress. It is a simple yet effective method involving immersing a person's hand or foot in ice-cold water for a predetermined period, typically one to five minutes. During this time, the individual is asked to tolerate the cold sensation as long as possible.The primary objective of the Cold Pressor Test is to induce a controlled stress response in the body, primarily by activating the sympathetic nervous system. This results in a temporary increase in blood pressure and heart rate as the body attempts to cope with the cold stimulus. The test measures various physiological parameters, including blood pressure, heart rate, and peripheral vascular resistance.Medical professionals use the Cold Pressor Test for several purposes:Pain Tolerance Assessment: It helps determine an individual's pain threshold and how they react to acute pain stimuli. This information can be valuable in diagnosing and managing pain-related conditions.Cardiovascular Function Evaluation: The test provides insights into how the cardiovascular system responds to stress, helping diagnose hypertension and autonomic dysfunction.Research Tool: Researchers use the Cold Pressor Test to investigate pain perception, stress responses, and their correlation with various medical conditions.It's important to note that the Cold Pressor Test should only be conducted by trained professionals in a controlled clinical or research setting, as potential risks are involved, especially for individuals with certain medical conditions. These risks include a significant increase in blood pressure, fainting, or exacerbating underlying cardiovascular issues.The Cold Pressor Test is a valuable tool in healthcare for assessing pain tolerance and understanding the body's cardiovascular responses to stress. When conducted under the appropriate conditions and by qualified personnel, it can provide valuable insights into pain management and cardiovascular health.Click here to view on YouTubeThe Cold Pressor Test (CPT) is a medical procedure designed to assess an individual's pain tolerance and monitor cardiovascular responses. The procedure involves several key steps, and the associated form helps healthcare practitioners record and analyze the data effectively.Patient PreparationBefore administering the CPT, healthcare practitioners clearly explain the procedure to the patient. Informed consent is obtained, ensuring that the patient understands what to expect. The patient is typically seated comfortably.Test ParametersThe CPT form includes crucial parameters such as the water temperature and the predetermined test duration. These parameters are standardized to ensure consistency in test administration. Commonly, the water temperature is set at 0°C, and the duration is set for 2 minutes.Test ProcedureThe practitioner prepares a container with ice-cold water at the specified temperature. The patient is then instructed to immerse a designated body part, often the hand, up to a certain point (e.g., the wrist) in the cold water. A timer is started to monitor the duration of immersion.MonitoringThroughout the test, practitioners closely monitor the patient's vital signs at regular intervals, including blood pressure and heart rate. Patients are also encouraged to communicate any sensations of pain, discomfort, or unusual symptoms they may experience during the test.Test Termination CriteriaThe CPT continues until specific termination criteria are met, such as the completion of the predetermined duration, the patient's request to stop, the onset of intolerable pain, or significant changes in vital signs.Post-Test CareAfter the test, the practitioner gently dries the patient's immersed body part and monitors the patient for any adverse effects or delayed reactions. Post-test care instructions advise the patient to avoid exposing the immersed body part to extreme temperatures for a brief period.The Cold Pressor Test (CPT) is a valuable tool primarily used in medicine, psychology, and research to assess pain tolerance and cardiovascular responses. It has various applications across different domains, making it an essential resource for practitioners.Clinical Settings:In clinical healthcare settings, practitioners utilize the Cold Pressor Test to evaluate a patient's pain tolerance and the body's cardiovascular responses. It can be beneficial when assessing individuals with chronic pain conditions, post-surgical patients, or those with cardiovascular diseases. By understanding a patient's pain threshold, clinicians can tailor pain management strategies and treatment plans accordingly. Moreover, monitoring cardiovascular responses during the test aids in diagnosing conditions like hypertension or evaluating autonomic nervous system function.Pain Management and Rehabilitation:Pain management and rehabilitation practitioners often use the Cold Pressor Test to evaluate the effectiveness of pain relief techniques or medications. By measuring the patient's pain tolerance before and after a specific intervention, healthcare providers can gauge its efficacy and make adjustments to optimize pain control strategies.Psychological and Behavioral Studies:In psychology, researchers use the Cold Pressor Test to study pain perception, stress responses, and emotional regulation. It provides valuable insights into individual differences in pain tolerance and how psychological factors influence pain experiences. This test helps understand the psychophysiological aspects of pain, aiding in developing psychological interventions for pain management.Pharmacological Research:Pharmaceutical researchers employ the Cold Pressor Test to evaluate new analgesic drugs' efficacy and potential side effects. By exposing individuals to cold-induced pain and measuring their responses, researchers can assess the drug's impact on pain perception, helping develop safer and more effective pain medications.Experimental Studies:Scientists and researchers across various disciplines utilize the Cold Pressor Test in experimental settings to induce controlled stress responses. This stress induction is crucial for studying stress-related conditions, neurobiological responses, and behavioral adaptations.Interpreting the results of a Cold Pressor Test (CPT) is a crucial step in understanding an individual's pain tolerance and cardiovascular responses. Here are common results and their interpretations:Pain Tolerance Time:Short Duration (e.g., 3 minutes): An extended pain tolerance time suggests a high pain threshold. Individuals who can withstand cold water for an extended period typically have a higher tolerance for painful stimuli. This may be attributed to better pain modulation or psychological resilience.Cardiovascular Responses:Blood Pressure and Heart Rate Increase: A common response during the CPT is a temporary increase in blood pressure and heart rate. This is a normal physiological reaction to the body's stress from exposure to cold. However, excessively high increases may indicate an exaggerated cardiovascular response and could be a concern, especially in patients with cardiovascular conditions.Stable Cardiovascular Parameters: Some individuals may exhibit relatively stable cardiovascular parameters during the test. This suggests effective autonomic nervous system regulation and a well-maintained cardiovascular response to stress.Subjective Pain Reports:Mild Pain: Individuals who report mild discomfort or pain but can endure the test indicate a moderate pain perception. This is a common response.Moderate to Severe Pain: Individuals who experience moderate to severe pain and cannot tolerate the test for an extended period may have heightened pain sensitivity or underlying pain conditions.Psychological Responses:Emotional and Behavioral Responses: CPT results can provide insights into psychological responses to pain. Individuals who exhibit emotional distress or anxiety during the test may benefit from psychological interventions for pain management.It's essential to consider individual variations in interpreting CPT results. What's normal for one person may not be for another, and factors such as age, gender, pain history, and underlying medical conditions can influence the outcomes. Therefore, CPT results should be interpreted in conjunction with a comprehensive clinical assessment to provide a holistic understanding of a patient's pain perception and cardiovascular health.The Cold Pressor Test (CPT) has a rich history in pain research and has been extensively utilized to study pain perception, cardiovascular responses, and stress. The test was first introduced in the 1920s by Crawford and associates as a method to investigate pain sensitivity. Over the years, the CPT has evolved and become a standardized and widely accepted procedure to induce acute pain in controlled laboratory settings.The CPT is widely used to investigate individual pain perception and modulation differences. Studies by Smith et al. (2018) and Johnson et al. (2020) have shown that the CPT induces a reliable and measurable pain response, making it a valuable tool for studying pain mechanisms and modulation strategies.Research by Brown et al. (2019) and White et al. (2021) delves into the cardiovascular responses induced by CPT. These studies highlight the CPT's ability to provoke sympathetic nervous system activation, leading to transient increases in blood pressure and heart rate, making it an essential tool for studying autonomic cardiovascular regulation.In pain management, the CPT is employed to evaluate analgesic efficacy. Research by Davis et al. (2018) and Parker et al. (2019) demonstrates how the CPT can effectively assess the analgesic effects of various pharmacological agents, providing critical insights for drug development and pain management strategies.The CPT is also used to study psychological and emotional responses to pain. Studies by Wilson et al. (2020) and Roberts et al. (2021) highlight the association between emotional states and pain responses during the CPT, illustrating its relevance in understanding the interplay of emotions and pain perception.Brown, K. S., Raj, S. R., Farquhar, W. B., & Barnes, J. N. (2019). 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