



## PES 241 - EXERCISE PHYSIOLOGY WEEK 2

### CONTROL OF THE INTERNAL ENVIRONMENT

Changes in body function through exercise reduce the stressfulness of exercise for the entire organism. E.g. muscle and used up oxygen, increased heart rate and breathing; exercise in the heat and sweat. The body has a normal temperature of 37°C or 98.6°F. Values above or below this signify a problem. This temperature does not depend on the external environment. There is therefore a mechanism that ensures this normalcy.

**HOMEOSTASIS:** It is defined as the tendency for living organisms to maintain a stable internal environment for their cells e.g. temperature, acidity, oxygen, glucose, etc.

The body maintains homeostasis through a process of **NEGATIVE FEEDBACK**. Here a disruption of homeostasis results in a functional change that causes a return of the cells environment toward normal. E.g. blood sugar (glucose) falls, the pancreas secretes glucose which speeds up the release of glucose into the blood from glucose stores in the liver. The release of glucose from the liver brings the blood sugar stores back to normal. (Homeostasis level). On the other hand, a carbohydrate rich meal will increase blood glucose above normal. This is also brought to normal by the action of insulin found in the same pancrease.

**STEADY STATE:** This is also seen as a constant internal environment that does not necessarily mean normalcy. It means a balance has been achieved between the demands placed on the body and the body's response to those demands. (Threshold).

For example during a sixty minute sub maximal exercise, a plateau of 38°C is reached between 40 and 60 minutes. Although there is that constancy, that temperature of 38°C is not seen as a normal body temperature.

Although, the concept of Homeostasis means an unchanging internal environment, this does not mean that the internal environment is absolutely constant, most physiological variables may vary around some 'set' value, and thus represents rather a dynamic constancy. An example is arterial blood pressure where during 8 minutes of rest, the mean values oscillate around 93mm Hg.

## **NATURE OF THE CONTROL SYSTEM**

The body has literally hundreds of control systems, with the overall goal of regulating some physiological variable at a near constant value. These changes reside in the cells themselves. Almost all the structures in the body work to help maintain homeostasis.

For example, the lungs (pulmonary system) and heart (circulatory system) work together to replenish oxygen and remove carbon dioxide from the extracellular fluid.

To fully understand how the system works to maintain a stable environment, we shall use the analogy of a simple nonbiological control system such as a thermostat-regulated heating and cooling system in a home. The temperature in the room is set at a constant and a rise or fall in this temperature will cause the system to produce heat or cold to achieve normalcy. (correction of the condition).

A biological control system is defined as a series of interconnected components that maintain a physical or chemical parameter of the body at a near constant value.

The general components of a biological control system are as follows:

(1) a receptor           (2) an integrating center and           (3) an effector

The system begins to operate when there is a stimulus (i.e. some detectable change in the environment) such as temperature, blood pressure, etc.

The stimulus excites the receptor (change detector) which then sends a message to the integrating centre (control box) which sends an appropriate output message to the effector (correcting centre) to bring the internal environment to normal. The returning of the internal environment to normal results in a decrease or increase in the stimulus that triggered the control system into action. This type of feedback is termed **NEGATIVE FEEDBACK**.

## **NEGATIVE FEEDBACK**

Most control systems of the body operate via negative feedback. An example of negative feedback can be seen in the respiratory system's regulation of the CO<sub>2</sub> concentration in extracellular fluid.

In this case, an increase in extracellular CO<sub>2</sub> above normal levels triggers a receptor, which sends information to the respiratory control center (integrating centre) to increase breathing. The effectors in this example are the respiratory muscles. The increase in breathing will lower extracellular CO<sub>2</sub> concentrations back to normal, thus establishing homeostasis.

This process is termed negative feedback in mind when studying how exercise response and adaptations to training occur, because the application of this principle often helps to sort out meaningful relationships between functional changes and to predict what responses or adaptations should occur e.g.

increase in body temperature should be followed by increased sweating and blood flow to the skin to speed up heat loss and return body temperature toward normal.

(Gain of a control system): The precision with which a control system maintains homeostasis is termed the gain of the system which can also be said to be the capacity of a control system. A control system with a large gain is more potent to correct an alteration and vice-versa.

Gain = amount of correction needed

Amount of abnormality that exist after correction.

Amount of correction required to maintain homeostasis to the amount of abnormality that exist after correction by the system.

Consider the following example of the feedback gain of the temperature control system during exposure to cold.

\* A person dressed in shorts leaves a comfortable room of temperature 22°C and enters a cold room of temperature 0°C for a twenty minutes stay. Upon entering the cold room. The person's body temperature is 37°C, but after twenty minutes it has decreased to 36°C. During the cold exposure, the control system automatically decrease skin blood flow to minimize heat loss and initiate shivering to increase heat production. Collectively these changes prevent body temperature from decreasing drastically. The feedback gain of the control system can be calculated as follows:

$$\begin{aligned}\text{Gain} &= \frac{22^{\circ}\text{C} - 0^{\circ}\text{C}}{37^{\circ}\text{C} - 36^{\circ}\text{C}} \\ &= \frac{22^{\circ}\text{C}}{1^{\circ}\text{C}} \\ &= \underline{22}\end{aligned}$$

The answer means that for each degree change in temperature that occurred during exposure to the cold room, there would have been a 22 times greater change in temperature if it were not for the control system.