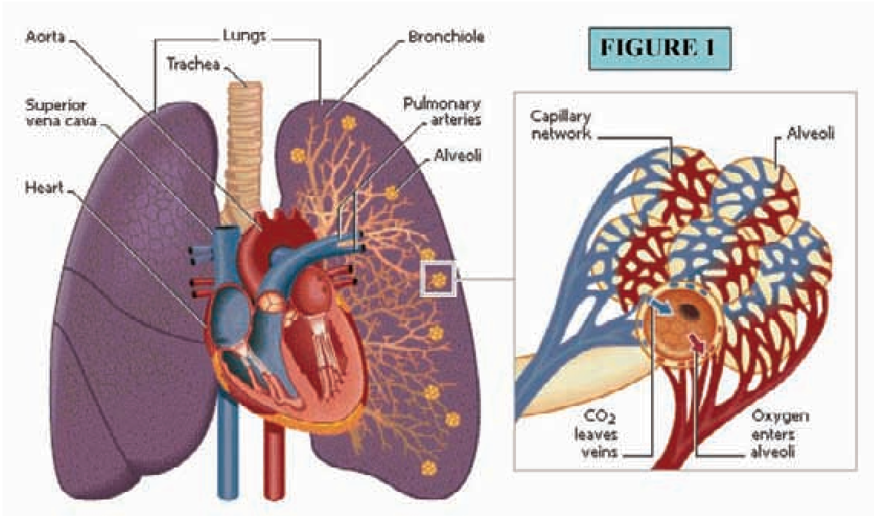
BREATH CONTROL

By Marcus Raab

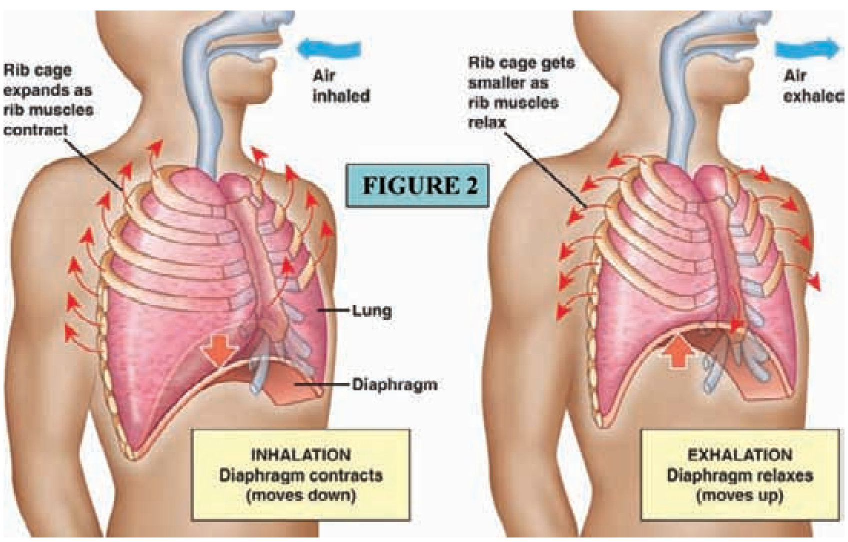
Our bodies must continually take in oxygen through the breathing process to continue functioning efficiently. The primary purpose of the respiratory system is to supply the blood with oxygen (O_2) for delivery to all parts of the body and to remove metabolic waste in the form of carbon dioxide (CO_2). The respiratory system does this through breathing.

The composition of inhaled or inspired air remains relatively constant. Air is primarily nitrogen (N_2) and several other inert gases, comprising 79.04 percent. Oxygen content is 20.93 percent and CO_2 comprises three-hundredths of a percent. Exhaled or expired air, excluding the excess water (H_2O) vapor, always contains more CO_2 (usually between two and five percent), less O_2 (usually 15 to 18 percent) depending on the individual and activity level, and slightly more N_2 (usually 79.04 to 79.6 percent) than the inhaled air. The slight increase in expired N_2 comes from the fact that the number of O_2 molecules taken in by the body are not replaced by the same number of CO_2 molecules produced through metabolic processes.



Air enters the respiratory system through the nose and the mouth. The sinus cavities and throat then warm the air. It then passes through a tube, the trachea, which enters the chest cavity. In the chest cavity, the trachea splits into two smaller tubes called the bronchi. Each bronchus then divides again forming the bronchial tubes. The bronchial tubes lead directly into the lungs where they further divide into many smaller tubes, which ultimately connect to tiny sacs called alveoli. The average adult's lungs contain about 300 million of these spongy, air-filled sacs surrounded by capillaries, providing a surface area of some 160 square meters (see Figure 1).

The blood arriving in the lungs from the rest of the body has a relatively high concentration of CO_2 and a relatively low concentration of O_2, compared to the inhaled air in the alveoli. Both gases diffuse in opposite directions along their concentration gradients, equalizing the concentrations between the blood and the air. The blood releases CO_2 into the alveoli. Meanwhile, the inhaled O_2 molecules in the alveoli diffuse through the capillaries into the arterial blood. The exchanged carbon dioxide follows the reverse path out of the lungs when we exhale (see Figure 2).



The lungs do not expand by themselves. Instead, they connect to the inside of the thorax via the inner and outer pleural membranes and comply with the movement of the chest. The physical process of inhaling occurs when the diaphragm, a dome shaped muscle sheet separating the thorax from the abdomen, contracts, pulling downwards, increasing the thoracic volume. Additionally, the external intercostal muscles connected to the rib cage, lift and expand the chest cavity, further increasing the thoracic volume. The increased volume of the lungs decreases the pressure inside. Atmospheric pressure air outside the body follows this low-pressure gradient to fill the lungs with fresh air.

Exhalation, on the other hand, is a relatively passive process. When the intercostal muscles and the diaphragm simultaneously relax, the tissues of the lungs and thorax stretched during inhalation naturally recoil. This in turn, reduces the thoracic volume and compresses the lungs thereby increasing the pressure inside the lungs. The increased pressure forces air out of the lungs through the mouth or nose.

The volume of air breathed in or out of the lungs during each breath is about one-half of a liter. This

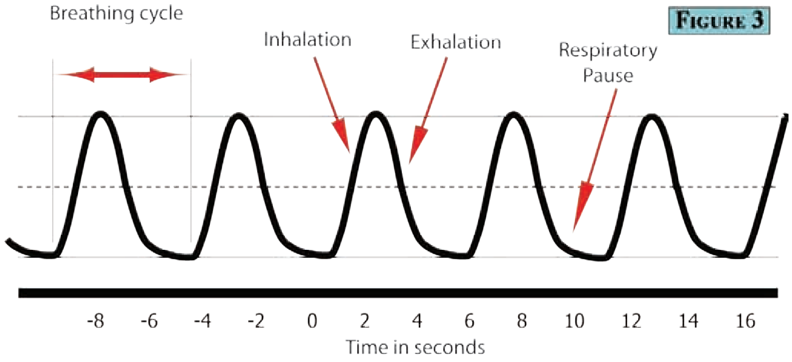


FIGURE 3

amount varies by individual and increases during exercise. The amount of residual air remaining in the lungs even after maximal forced exhalation is about one-and-a-half liters.

UNCONSCIOUS CONTROL MECHANISM

The act of breathing is unconsciously regulated by specialized centers in the brainstem, which automatically regulate the rate and depth of breathing depending on the body's needs. It is a rising concentration of CO_2—not a declining concentration of O_2—that plays the major role in regulating the ventilation of the lungs.

Reacting reversibly with the water in blood, carbon dioxide released from cellular metabolism produces carbonic acid, lowering the pH.

$CO_2 + H_2O \longrightarrow HCO_3^- + H^+$

This drop in the blood's pH stimulates chemoreceptors in the carotid and aortic bodies in the blood system to send nerve impulses via the vagus nerve to the respiration center in the medulla oblongata and pons in the brainstem. Nerve impulses sent through the phrenic and thoracic nerves control the action of the diaphragm and intercostal muscles. As the lungs expand, the ends of the centripetal fibers of the vagus nerve are stimulated, leading to a retardation of the actions of the respiratory center, allowing the intercostal muscles and the diaphragm to relax, causing exhalation.

The rate of cellular respiration, and hence O_2 consumption and CO_2 production varies with level of activity. Vigorous exercise can increase the demand for oxygen by over twenty times. Lactic acid produced by anaerobic exercise can also lower blood pH. The respiratory center responds by increasing the number and rate of nerve impulses. This causes an increase in the rate and depth of breathing which soon brings the CO_2 concentration of the alveolar air, and then of the blood, back to normal levels.

The carotid body in the carotid artery does have receptors that respond to a drop in oxygen concentration. Their activation is important in certain situations, e.g., at high altitude, where oxygen supply is inadequate, even though there may have been no increase in the production of CO_2.

CONSCIOUS CONTROL

Breathing is one of the few bodily functions that (within limits) is controlled both consciously and unconsciously.

Normally, the rate of respiration at rest is between 12 to 15 breaths per minute. The inhalation phase takes about one second followed almost immediately with exhalation, which takes slightly longer. A pause of a second or two between the end of exhalation and the beginning of the next inhalation occurs as the CO_2 content of the blood increases to the point where it triggers the next cycle to start. Controlling and extending this respiratory pause occurs in many activities. For example, in swimming, cardio fitness or vocal training, one learns to discipline their breathing. Even human speech is dependent on breath control.

It should be obvious that the shooter must not breathe while aiming, as the movement of the abdomen, chest and shoulders causes the gun to move significantly making an accurate shot almost impossible. Therefore, the shooter must interrupt their normal breathing cycle in some way for a short period, long enough to settle the hold, aim and shoot the shot.

Figure 3 shows a hypothetical pneumograph of the normal breathing cycle. The lowest point on the graph is the natural respiratory pause. This is the point where the chest muscles are relaxed and the air pressure inside the lungs is essentially equal to that surrounding the outside of the body. At this point, there is no need to exhale further as the CO_2 level in the blood has not reached the concentration necessary to initiate the signal to inhale. In a healthy person, this pause can extended for 12 to 15 seconds without difficulty or experiencing an unpleasant urge to breathe. Ventilating the lungs with deeper inhalations and exhalations before interrupting the breathing cycle can further extend this time.

Figure 4 shows the typical breathing cycle for rifle shooting. Normal breathing should continue until the athlete begins to aim and the sights settle on the bull's-eye. The breathing cycle is intentionally interrupted for six to eight seconds during which time the shooter will either fire the shot or reject that attempt and start the process again. Though the shooter may be able to hold their breath longer than eight to ten seconds, this causes problems with maintaining clear vision as the blood O_2 level is depleted. Additionally, the urgent feeling of the need to breathe due to the buildup of CO_2 in the blood ultimately becomes a distraction from the precise aiming task.

While attempting to fire a shot, a beginner will often take a deep breath and hold it in with his or her lungs fully inflated. Though he or she received instruction to avoid breathing during a shot, this is incorrect. Because the intercostal muscles are under tension holding the rib cage in its expanded position, the shooter will quickly feel uncomfortable, negatively influencing the stillness of the rifle.

Some experienced shooters pause their breathing after

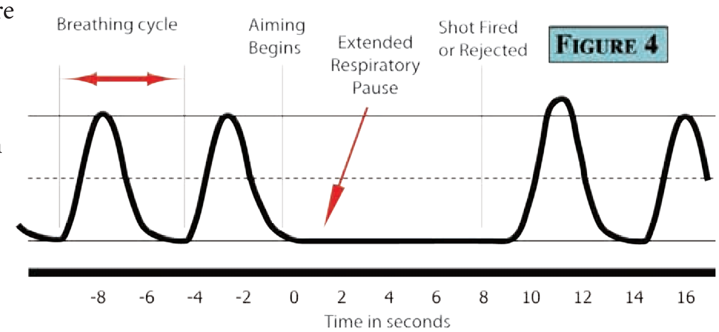


FIGURE 4

several respiratory cycles of decreasing depth, starting with a deep breath and shallower inhale and exhale sequences until obtaining hold refinement (see Figure 5). This technique variation provides some fresh air to the lungs without inducing the major disturbance to the aiming position that a normal breath would.

A few shooters have experimented with inhaling partially after the normal pause (see Figure 6) or stopping their breathing prematurely before the natural pause (see Figure 7). These techniques, however, are potentially problematic as the amount of breath inhaled or held from shot to shot may not be consistent, leading to vertical alignment deviations. This often results in holding too long as they attempt to adjust their point of aim onto the target.

Another pitfall of purposely holding air in the lungs is that of air leakage. As the shooter aims, especially in a sling position, the air is able to escape slowly from the lungs through the nose or mouth. Thus, the position's natural point of aim will gradually drift higher. In the standing position, it would sink lower. Add to this an over-aiming situation with declining visual acuity and the shooter can easily miss the center. It is much more consistent to exhale to the natural respiratory pause, which is the recommended method.

Figure 5

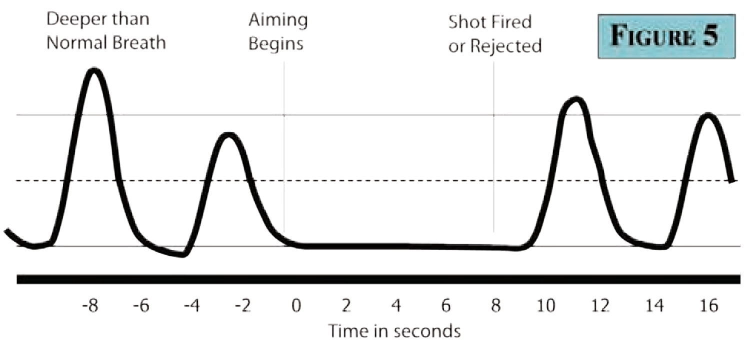


Figure 6

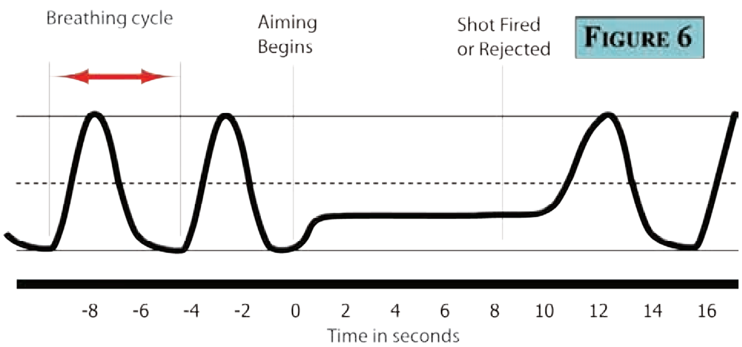
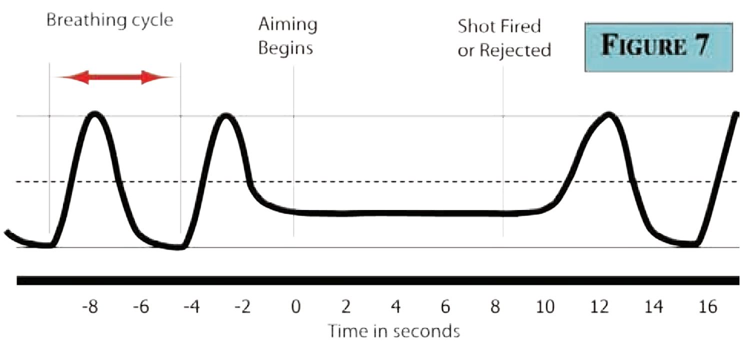


Figure 7



ABDOMINAL BREATHING VS. CHEST BREATHING

Under stress, breathing usually becomes shallow and rapid, and occurs high in the chest as the body goes into the "fight or flight" response. Shallow, chest-level breathing, when rapid, leads to hyperventilation. Hyperventilation, in turn, can cause physical symptoms associated with anxiety, such as light-headedness, dizziness, heart palpitations, or tingling sensations.

When relaxed and calm, you breathe more fully, more deeply and from your abdomen. Moreover, when you breathe from your abdomen, you inhale about one-half of a liter of air. When you breathe from your chest, you inhale about half of that amount. The more air you inhale translates directly into increased oxygen supply to the brain and musculature.

Additionally, abdominal breathing by itself can trigger a relaxation response, improve concentration and reduce anxiety by stimulating the parasympathetic nervous system. This branch of the autonomic nervous system promotes a state of calmness and quiescence. It works in a fashion exactly opposite to the sympathetic branch of the nervous system, which stimulates a state of arousal and the physiological reactions underlying panic or anxiety. If a shooter's mind is racing, it is difficult to focus his or her attention. Abdominal breathing helps to quiet the mind.

Some people do not even realize that they are breathing from the chest rather than the stomach. By changing their breathing pattern from their chest to their abdomen (stomach area), they can reverse the cycle and transform their breathing into a built-in tool for anxiety control.

You can see for yourself if you are stomach breathing by lying on your back and placing your hands on your stomach. Your stomach should rise and fall as opposed to your chest rising and falling. In order to practice this, picture your stomach filling up as a balloon would. Every time you breathe in, your stomach fills up and the balloon and rises, and every time you breathe out, your stomach flattens. During this time, your chest should stay mostly still.

Chest breathing is not always a negative. It may also be a useful tool for the shooter. While we want to be relaxed and calm when firing a shot, a chest breath or two immediately after the shot can reenergize the shooter especially during long courses of fire. Coaches should suggest that athletes employ chest breathing immediately after the shot to invigorate and begin replenishing the blood oxygen level. Additionally, athletes should switch to stomach breathing to relax into the position prior to a shot. This procedure helps prevent premature fatigue over long courses of fire and provide the basis for a solid shot plan.