The Role of Pulse Oximetry in Athletic Health Care

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Athletic trainers and therapists must be proficient at obtaining vital signs and be able to interpret physiological warning signs. In an academic program it is one of the first clinical skills a student learns. Historically, pulse and respiration rate were the first vital signs taken, because they required only a timepiece for measurement. Blood pressure and body temperature measurements came later and required instrumentation in order to obtain them. The instruments used were relatively inexpensive, reusable, and noninvasive. Other vital signs such as level of consciousness, skin color and temperature, capillary refill, and pupillary reaction are also important in making critical decisions in athletic health care (American Academy of Orthopedic Surgeons, 1998). Pulse oximetry, compared with other vital signs, is new and can play an important role in the overall health care of athletes.

What Is Pulse Oximetry?

As hemoglobin passes through the lungs it picks up oxygen, forming a red-colored compound called oxyhemoglobin. Tissue oxygenation depends on the amount of oxygen delivered to the tissues and the ease with which hemoglobin gives up oxygen once it reaches the tissues. Low oxygen content in the body tissues, usually because of a reduction in the oxygen level in the blood, is called hypoxemia and can be detected with an oximeter.

The two types of oximeters are the co-oximeter and the pulse oximeter. There are portable and stationary models of each type. The pulse oximeters come in three different models: desktop, handheld, and finger. The co-oximeter has been the standard for measuring arterial oxyhemoglobin saturation, and it involves sampling arterial blood by way of an arterial puncture or in-dwelling catheter. Advancements in diagnostic technologies have made possible the noninvasive assessment of hemoglobin saturation through pulse oximetry. Although pulse oximetry is technically less demanding than using a co-oximeter, it is inherently limited by its inability to assess carboxyhemoglobin and methemoglobin.

Oxygen-saturation measurements were first introduced and described by Takuo Aoyagi of Japan in 1972. In the 1980s Nellcor produced an accurate, affordable, and noninvasive pulse oximeter (Tierney, Whooley, & Saint, 1997; Yelderman & New, 1983). The Technology Assessment Task Force of the Society of Critical Care Medicine defines “the appropriate clinical uses of pulse oximetry to fall into one of two broad categories: as a warning system based on continuous real-time measurement of arterial desaturation, or as an end-point for titration therapeutic interventions” (1993). The Australian and New Zealand College of Anaesthetists policy document (1995) states that “a pulse oximeter must be in use for every anaesthetized patient” (p. 18).

Key Points

- The finger pulse oximeter is the least expensive and most portable of the available oximeter units.
- Values obtained with pulse oximetry become less accurate if arterial oxyhemoglobin saturation is less than 70%.
- Moderate to severe hypoxia occurs at <90% saturation as measured at sea level.
- Key Words: vital signs, hypoxemia, oxygen saturation
The reliability and simplicity of pulse oximetry have led some to promote its use as a fifth vital sign (Mower, Sachs, Nicklin, & Baraff, 1997; Neff, 1988; Tierney et al., 1997). Pulse oximetry has also been found to provide highly accurate results during exercise studies, especially when using the finger-probe-equipped units (Barthelemey, Geyssant, & Riffat, 1990; Martin, Powers, & Cicale, 1992; Mengelkoch, Martin, Cicale, & Huang, 1992).

**How to Use a Finger Pulse Oximeter**

The athletic trainer or therapist clips the pulse oximetry unit onto the athlete's finger, "sandwiching" the arterial vascular bed between a light source and a photo detector (see Figure 1). Light of two wavelengths, one red and one infrared, is then transmitted through the vascular bed of the finger. The amount of light absorbed is measured by calculating the absorption at the two wavelengths. The pulse and oxygen-saturation levels are displayed digitally on the monitor. The computer in the oximeter is capable of distinguishing pulsatile flow from other more static signals such as tissue or venous signals. The pulse oximetry instrument takes about 10 s to record the initial reading and then gives a continuous visual display of the pulse rate and oxygen-saturation levels of the athlete. The pulse rate reading is based on a per-minute ratio. The oxygen-saturation reading is based on a percentage of the total amount of oxygen bound to hemoglobin in the red blood cells in comparison with the total amount possible. As an example, if your oxygen saturation is 50%, your hemoglobin is carrying only half of what it is capable of carrying. An athlete experiencing hypoxia would be one who has a decrease of oxygen to the tissue in spite of adequate blood flow.

**Table 1. Oxygen Saturation Levels**

<table>
<thead>
<tr>
<th>Level</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Normal</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>Mild hypoxia</td>
<td>94–90%</td>
</tr>
<tr>
<td>Moderate to severe hypoxia</td>
<td>&lt;90%</td>
</tr>
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Low oxygen-saturation levels give the athletic trainer or therapist an indication of the level of hypoxia, as classified in Table 1. It should be noted that values obtained with pulse oximetry become less accurate if arterial oxyhemoglobin saturation is less than 70% (Goodfellow, 1997).

**Finger Pulse Oximeter Use in the Athletic Health Care Setting**

A wide range of sensors are available for different body locations, but for field-based purposes the finger pulse oximeter gives the athletic trainer or therapist the flexibility to carry it in a personal field kit. The finger pulse oximeter has also been proven more stable than ear-probe pulse oximeters in exercise-related studies (Barthelemey et al., 1990; Martin et al., 1992; Mengelkoch et al., 1992). The finger pulse oximeter weighs only 2 oz and is the least expensive of the three models, at under $400 per unit (Nonin Medical Inc., see Figure 2).

Traditionally, pulse oximetry has been used to monitor subjects in a variety of settings and conditions: anesthesia, labor and delivery, emergency treatment (both in the field and clinically), cardiorespiratory compromise, cardiac obstructive pulmonary disease, sleep apnea, acute anemia from hemorrhage, and during air flights. Athletic training applications include cardiorespiratory complications such as asthma, upper respiratory track infections, bronchitis, and hyperventilation.

**Choices**

Pulse oximetry could complement the other vital signs when an athletic trainer or therapist has a decision to make.

**Refer an Athlete to an Emergency Room**

Athletic trainers and therapists often face decisions on when to refer an athlete to the emergency room,