Official Guidelines from the Cardiovascular and Pulmonary Section

Supplemental Oxygen Utilization During Physical Therapy Interventions

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ABSTRACT/SUMMARY

The use of supplemental oxygen is an important component of disease management in many patients who demonstrate hypoxemia at rest and/or with activity since supplemental oxygen can assist individuals in improvement of functional performance. Although the evidence on the use of long term or intermittent supplemental oxygen is not particularly robust, the majority of the evidence supports the use of supplemental oxygen to improve exercise tolerance and prevent long term effects of hypoxemia such as pulmonary hypertension and subsequent cor pulmonale. A need exists for recommendations on the use of supplemental oxygen in the clinical setting as physical therapists are often required to utilize supplemental oxygen with patients in all settings but currently no national recommendations, position statements, or guidelines exist for physical therapy practice. This position statement, developed following an extensive search of the literature, provides the following guidelines for physical therapists regarding assessment and management of supplemental oxygen for patients with cardiopulmonary diseases.

To safely maximize and optimize the functional ability of the patient, the role of the physical therapist is to: (1) assist with titration of supplemental oxygen, (2) discuss in safety with activity, (3) present appropriate exercise prescriptions to increase functional performance, and (4) instruct patients in use of appropriate breathing exercises to optimize supplemental oxygen and decrease breathlessness.

Key Words: supplemental oxygen, hypoxemia, pulmonary disease, heart failure

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INTRODUCTION AND PURPOSE

The use of supplemental oxygen is an important component of disease management in patients diagnosed with a variety of cardiac and/or pulmonary disease or dysfunction, such as chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), heart failure (HF), and cystic fibrosis (CF). The number of people living with COPD in the United States is estimated to be between 12[1] and 23[2] million. Additionally, approximately 100,000 people are diagnosed with ILD. Heart failure is a major public health issue, with a prevalence of over 5.8 million in the United States, and over 23 million worldwide.[3] Cystic fibrosis affects 30,000 children and adults in the United States and 70,000 worldwide.[4] Physical therapists have an integral role in managing supplemental oxygen needs as they relate to achieving optimal function since patients receiving supplemental oxygen or who may need supplemental oxygen at rest and/or with activity are found in every practice setting.

The purposes of this position statement are to: (1) provide an overview of the impact of hypoxemia and the impact of appropriate supplemental oxygen delivery on function, (2) to discuss the benefits of supplemental oxygen use in a variety of patient/client groups, and (3) to present the role of physical therapy in the use of assessment and titration of supplemental oxygen in patients especially during activity, including legal implications of titration. The goal of these recommendations is to improve care for patients with supplemental oxygen needs, and improve the management and use of supplemental oxygen in patients with cardiopulmonary dysfunction.

Process

A task force was created in 2010 by the Cardiovascular and Pulmonary Section of the American Physical Therapy Association (APTA) that included clinicians with specific areas of practice and was charged to develop recommendations on supplemental oxygen utilization based upon current evidence. (See Appendix 1 for members and expertise represented.) The recommendations in this

document represent consensus of the task force based on evidence from English-language publications up to 2012 obtained by searching MEDLINE and CINAHL with the key words supplemental oxygen, chronic obstructive pulmonary disease and supplemental oxygen, cystic fibrosis and supplemental oxygen, long term supplemental oxygen, interstitial lung disease and supplemental oxygen, carbon dioxide (CO_2) retention, and supplemental oxygen and supplemental oxygen guidelines. These recommendations were presented at the Combined Sections Meeting of the APTA in 2010. Feedback was sought from the Cardiovascular and Pulmonary Section Board of Directors and final approval of these recommendations was given on March 28, 2014.

A systematic review of the literature was performed, followed by development of recommendations by the task force based upon the strength of the evidence. A thorough review of the evidence found that the use of supplemental oxygen resulted in improved exercise tolerance, decreased work of breathing, decreased dynamic hyperventilation as well as a decrease in breathlessness in individuals that demonstrated decreases in blood oxygen saturation (SpO_2) with exercise. However, physical therapists often report fear of use of supplemental oxygen with many populations as well as having concerns with titration of supplemental oxygen with activity.

Hypoxemia and Its Impact on the Individual

Signs and symptoms of hypoxemia include headache, breathlessness or severe dyspnea, palpitations, angina, restlessness and tremors.[5-7] In severe hypoxemia, when oxygen levels in the blood are extremely low, the signs and symptoms include impaired judgment and a progressive loss of cognitive and motor function that worsens as the hypoxemia progresses.[5-7] Loss of consciousness may develop with severe hypoxemia.[5-8] Assessment of the signs and symptoms of hypoxemia are important for the physical therapist who may not be able to monitor oxygen saturation via pulse oximetry regularly (See Box 1).

Severe physiologic consequences occur when hypoxemia develops and continues over time. When the partial pressure of oxygen in arterial blood (PaO_2) falls below 55 mm Hg a subsequent increase in minute ventilation occurs as well as a decrease in partial pressure of carbon dioxide ($PaCO_2$). This results in dilation of peripheral vascular beds and a compensatory rise in heart rate as well as a rise in cardiac output to increase oxygen delivery to tissues.[9-11] Regional pulmonary vasoconstriction occurs when there is alveolar hypoxia resulting in shunting of blood in the lungs. Long-term hypoxemia will lead to pulmonary hypertension, increasing the work on the right side of the heart, leading to right heart dysfunction and subsequently failure (cor pulmonale).[9-11] Chronic hypoxemia with cor pulmonale results in a poor prognosis and a 32% to 100% increase in risk of mortality.[9-14]

Box 1. Signs/Symptoms of Hypoxemia[5-8]

- Impaired judgment
- Progressive loss of cognitive and motor functions as the hypoxemia progresses
- Decreased exercise tolerance
- Loss of consciousness develops with severe hypoxemia
- Other signs and symptoms of hypoxemia include headache, breathlessness or severe dyspnea, palpitations, angina, restlessness, and tremors

Acute Effects of Supplemental Oxygen

The short-term effects of utilizing supplemental oxygen include an improvement in breathlessness in an individual with a decreased PaO_2 and SpO_2 at rest as well as a decreased breathlessness in individuals who demonstrate a decrease in SpO_2 with exercise.[15,16] Short-term use of supplemental oxygen during exercise improves exercise tolerance in those with mild, moderate, or even severe hypoxemia during exercise.[15,16] Swinburn et al[16] showed that the use of supplemental oxygen decreased the minute ventilation in individuals who were breathless and hypoxemic both during rest and activity. O'Donnell et al[17] identified that a decrease in dynamic hyperinflation in individuals with chronic disease occurred when utilizing supplemental oxygen for breathlessness. Similar to O'Donnell, Bye et al[18] demonstrated an improvement in ventilatory muscle function with the use of supplemental oxygen and Criner[7] and Celli and MacNee[8] showed altered favorable muscle recruitment with supplemental oxygen. Manning and Schwartzstein[5] also found an inhibition of the central ventilatory response to hypoxemia with the use of short-term supplemental oxygen.

Dean and associates[19] found the use of supplemental oxygen alleviated hypoxic pulmonary vasoconstriction as well as improved hemodynamics including a decrease in peripheral vascular resistance and an increase in cardiac output. When there is an increase in supplemental oxygen delivery, a decrease in breathlessness will occur as well as a decrease in the perception of dyspnea, which will lead to an increase in exercise performance.[15]

Chronic Effects of Supplemental Oxygen

Two landmark prospective controlled studies performed in the early 1980s are still the only current evidence discussed about long-term supplemental oxygen use. The two trials were the Nocturnal Oxygen Therapy Trial (NOTT)[20] and the British Medical Research Council (MRC) long-term domiciliary supplemental oxygen therapy trial.[21] Early studies were not controlled but provided evidence of a reduction in mortality and a reduction in the development of cor pulmonale when supplemental oxygen was used continuously for 7 to 41 months.[20,21] The study population included individuals who were severely hypoxemic with elevated hematocrit, elevated pulmonary artery pressure, and respiratory acidosis.

The NOTT trial compared continuous use of supplemental oxygen versus nocturnal supplemental oxygen use only. The results of the NOTT trial showed

an increase in mortality in individuals who used only the nocturnal supplemental oxygen versus the individuals who used supplemental oxygen continuously.[20] The results of the MRC long-term supplemental oxygen study found that long-term oxygen therapy prevented a progressive decrease in PaO_2 and an increase in pulmonary vascular resistance without an increase in $PaCO_2$.[21] The conclusions from these two studies were that, in individuals with severe hypoxemia, nocturnal supplemental oxygen use was better than no supplemental oxygen therapy and continuous supplemental oxygen was better than nocturnal supplemental oxygen therapy alone. Little evidence exists since those trials were published and no studies have shown a benefit of long-term oxygen therapy with mild or moderate hypoxemia. In addition, no studies have shown a benefit of long-term oxygen therapy when supplemental oxygen is prescribed for exercise-induced oxygen desaturation only.[22] Table 1 provides the indications for long-term supplemental oxygen therapy as a result of the available evidence.

Supplemental Oxygen Use with Physical Activity

Supplemental oxygen has been utilized during physical activity for individuals who are hypoxemic and for those who demonstrate oxygen desaturation with activity. Supplemental oxygen has also been used to improve exercise training effects in individuals who were normoxemic at rest and had a SpO_2 above 88% with activity.[12] Emtner et al[12] utilized an intervention of 7 weeks of high intensity training in individuals with COPD and observed improvement in the training work rate in groups trained both with and without supplemental oxygen, yet the supplemental oxygen trained group increased the training work rate more rapidly than the group that trained without it.[12] Puhan et al[13] performed a systematic review of supplemental oxygen interventions to enhance the effectiveness of physical exercise, yet failed to find a beneficial effect of supplemental oxygen for improving exercise tolerance possibly due to small samples in the reviewed randomized controlled trials as well as poor methodological quality of the studies. Therefore, although there is some evidence of the benefit of supplemental oxygen for physical activity, there is a need for more research in this area.

Published Guidelines/Statements on Supplemental Oxygen Therapy

Currently few national guidelines on the use of supplemental oxygen exist and none address the needs of physical therapists working in all care settings with all patient populations. The American Association of Respiratory Care published guidelines in 2002 regarding supplemental oxygen therapy for adults in acute care facilities, yet these guidelines fail to address titration with activity, nor do they address the variety of populations that are treated by physical therapists.[23] In 2013 the Australian and New Zealand Lung Associations published the *Australian and New Zealand Guidelines for Management of COPD*[24,25] yet these guidelines do not address other populations. The APTA has a position statement regarding pharmacology in physical therapy practice that has been interpreted to include supplemental oxygen.

In addition, there are a few position statements from other organizations on supplemental oxygen use with heart failure. The most current indications for the use of supplemental oxygen in patients with heart failure include maintaining the SpO_2 at least 89% to 90% and maintaining the PaO_2 at least 56 mm Hg.[26] The Centers for Medicare and Medicaid Services (CMS)[27] and American Association for Respiratory Care (AARC)[23] guidelines specifically mention the use of supplemental oxygen in patients with heart failure stating, "Long-term supplemental oxygen therapy is indicated for hypoxemia ($PaO_2 \leq 55$ mm Hg or $SaO_2 \leq 88\%$ in subjects breathing room air, OR PaO_2 of 56-59 mm Hg or $SaO_2/SpO_2 \leq 89\%$ in association with specific clinical conditions such as cor pulmonale, heart failure, or erythrocythemia with a hematocrit > 56) at rest, during sleep, during ambulation, or during exercise."

Effects of Supplemental Oxygen Use in Specific Cardiopulmonary Diseases

Individuals with COPD gain many benefits from oxygen supplementation but unfortunately, they are a population that is often not given optimal supplementation due to the incorrect belief that all COPD patients would have a decreased drive to breathe if given too much oxygen. Long-

Table 1. Indications for Long-term Supplemental Oxygen Therapy. Adapted from Criner GJ. Effects of long-term supplemental oxygen therapy on mortality and morbidity. *Respir Care*. 2000;45:105-118.

Absolute	$PaO_2 \leq 55$ mm Hg or $SpO_2 \leq 88\%<$
In presence of cor pulmonale	PaO_2 55-59 mm Hg or $SpO_2 \leq 89\%$, ECG evidence of right atrial enlargement, hematocrit > 55%, congestive heart failure
Only in specific situations	$PaO_2 \geq 60$ mm Hg or $SpO_2 \geq 90\%$; with lung disease or sleep apnea who also have nocturnal desaturation that is not corrected by CPAP
If the patient is normoxemic at rest but desaturates during exercise or sleep	Supplemental oxygen should be prescribed if PaO_2 falls below 55 mm Hg during exercise or sleep; also consider nasal CPAP or bilevel positive airway pressure

Abbreviations: CPAP = continuous positive airway pressure

term supplemental oxygen use in individuals who have been diagnosed with COPD has been demonstrated to decrease the incidence of pulmonary arterial hypertension (PAH). In those with documented pulmonary hypertension, it has been shown to stabilize the condition and prevent further increases in PAH.[10] In addition, reduced morbidity and mortality were recorded in individuals who used continuous supplemental oxygen, which was associated with a reduction in development of right ventricular dysfunction/cor pulmonale.[20,21,28] Supplemental oxygen also prevents the compensatory increase in red cell mass and therefore decreases incidence of polycythemia.[22] Evidence from clinical studies have demonstrated increased exercise capacity in individuals with COPD with use of oxygen supplementation as well as a reduction in the number of pulmonary exacerbations, cardiac arrhythmias, and episodes of myocardial ischemia.[29-32] Neuropsychiatric function[33] and quality of life have also been shown to be improved with long-term oxygen supplementation.[35-37] Supplemental oxygen use in individuals with CF has been shown to decrease arterial hypoxemia, reduce the work of breathing, decrease dyspnea, increase oxygen delivery to the working muscles, delay the onset of anaerobic threshold, and prevent the development and/or progression of pulmonary hypertension.[38-40]

In individuals with ILD, the addition of supplemental oxygen increases exercise tolerance,[18,41] maximum work load,[41,42] and minute ventilation.[41] In a study by Naji et al[43] patients receiving long-term oxygen therapy demonstrated a greater improvement in treadmill test performance as compared to those not receiving oxygen therapy. In patients with ILD, supplemental oxygen requirements were found to be predictive of mortality, with higher supplemental oxygen requirements more indicative of higher mortality, independent of 6 minute walk test results and pulmonary function.[44]

Role of the Physical Therapist with Patients Receiving Supplemental Oxygen Therapy

If the original supplemental oxygen prescription does not include a specified target SpO_2 value the prescribing health care provider should be contacted. Once there is a prescription for a specific oxygen saturation target level to be maintained during rest and activity (for example, maintain $SpO_2 > 90\%$), the physical therapist may titrate the supplemental oxygen flow to maintain SpO_2 at or above the specified value. To assist the physical therapist with clinical decision making regarding supplemental oxygen titration, an algorithm has been provided in Figure 1.

At times the oxygen delivery device the patient is using may be different from the one prescribed and the reason should be investigated. Signs and symptoms of distress and changes in heart rhythm must be closely monitored during a physical therapy intervention, as they are indications of intolerance to activity. In the event of an emergency situation that warrants the immediate administration of supplemental oxygen, the physical therapist may provide the supplemental oxygen but the physician should be notified and an order written following the event.[45]

The following additional recommendations should be utilized to guide physical therapists providing interventions for patients in acute care and especially the intensive care unit (ICU) that are receiving supplemental oxygen:

- In the event that the prescription is not written as "Keep SpO_2> ___%" the clinician should contact the referring practitioner to attempt to obtain a standing order.
- Baseline vital signs including oxygen saturation must be measured before any activity.
- An assessment should be performed to determine any changes in clinical status since the previous therapy session.
- Oxygen saturation should be monitored closely when a patient is prescribed oxygen at rest and/or with activity during physical therapy interventions.
- At the end of any physical therapy intervention, the supplemental oxygen must be returned to the delivery device and flow rate used prior to the intervention as oxygen is specifically prescribed at rest based upon resting arterial blood gases. In the event a patient is experiencing signs or symptoms of hypoxemia and cannot maintain adequate oxygen saturation at the amount of supplemental oxygen prescribed at rest, the prescribing health care provider should be contacted immediately.

Precautions with Supplemental Oxygen Titration

Some concern exists in the medical community regarding titrating supplemental oxygen in individuals that have elevated $PaCO_2$ with activity (for example, individuals who retain CO_2) due to the results of the long-term supplemental oxygen studies that observed hypoventilation in some individuals when supplemental oxygen was increased *at rest*.[20,21] The studies demonstrated a decrease in "drive to breathe" or hypoventilation when the supplemental oxygen was increased at rest only. Aerobic exercise requires oxygen to be present in the bloodstream in sufficient quantity and present in the muscle to be utilized by the mitochondria to produce energy for exercise. When individuals with pulmonary disease exercise, their gas exchange may worsen, therefore decreasing the amount of oxygen in the blood and causing subsequent disassociation of oxygen from hemoglobin. Individuals with an elevated $PaCO_2$ at rest who demonstrate a decrease in supplemental oxygen saturation *with activity* benefit from increased supplemental oxygen during activity. Supplemental oxygen should be titrated to keep $SpO_2 > 90\%$ *with activity* but returned to their baseline supplemental oxygen flow *at rest*. Although supplemental oxygen in patients with increased $PaCO_2$ may theoretically worsen hypercapnia, any increase in $PaCO_2$ in patients receiving long-term supplemental oxygen therapy is usually small and well tolerated. In two large trials of long-term supplemental oxygen therapy, hypercapnia was not a problem.[20,21] In a small subset of individuals who exhibited CO_2 retention with increased supplemental oxygen, the development of increased hypercapnia was accompanied by an obvious decrease in respiratory rate and depth, as well as the development of disorientation or

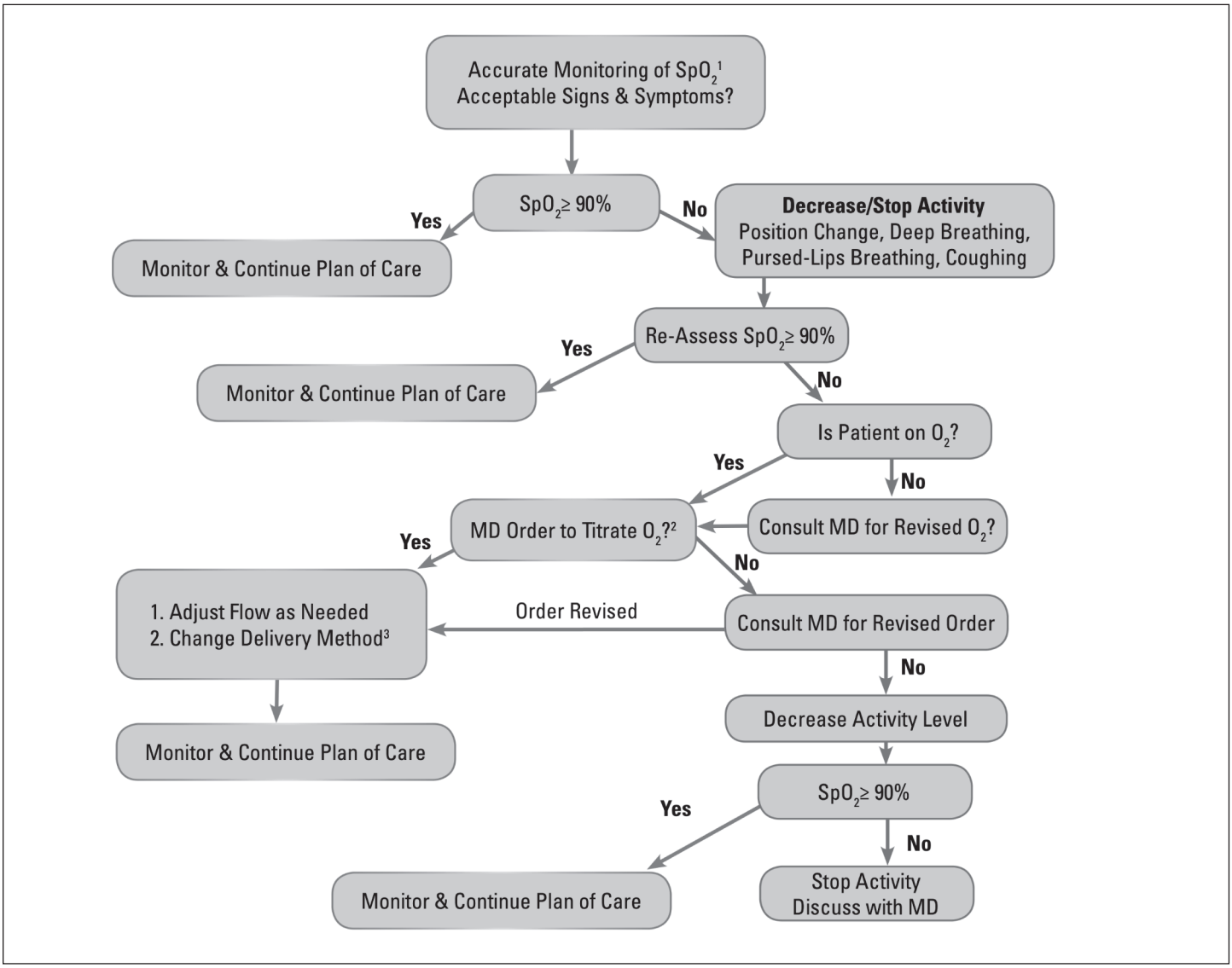


Figure 1. Guide to decision making regarding supplemental oxygen.

Abbreviation: O_2, supplemental oxygen
[1]Correct use of oxygen monitoring requires individual to palpate pulse and compare to reading of pulse rate on pulse oximetry
[2]Order example: "Titrate oxygen to maintain SpO_2 > ____%
[3]Oxygen delivery system needs to be changed to maintain or improve oxygenation

somnolence.[20,21] Therefore, individuals with CO_2 retention who demonstrate increased disorientation or a decrease in respiratory rate and/or depth along with no increase in SpO_2 when supplemental oxygen is increased with activity are not candidates for supplemental oxygen with activity.

Additional Considerations Regarding Supplemental Oxygen Therapy

Assessment of oxygen saturation by physical therapists is typically performed using a pulse oximeter. Although very useful, pulse oximeters, like any other monitoring tool, need to be utilized correctly. Physical therapists must be aware that inaccurate readings can occur. Therefore, it is important to recognize and minimize limitations that hinder accuracy of pulse oximeters (See Box 2) and to monitor heart rate response and respiratory rate response.[50-53]

Proper documentation during therapeutic activities is crucial. Not only are vital signs important to record but any signs and/or symptoms a patient exhibits relating to possible hypoxemia and respiratory fatigue must be noted. When documenting oxygen saturation, the following should be included:

- The supplemental oxygen delivery system utilized as well as the amount of supplemental oxygen the patient required during rest and/or exercise
- The amount of time the patient tolerated a certain activity before a low value was noted as well as the amount of time the patient required to recover to an appropriate oxygen saturation value
- Any special circumstances surrounding the response to exercise or recovery following exercise
- Interventions that were employed to assist the patient raise SpO_2 or to decrease the symptoms of dyspnea, such as pursed lip or diaphragmatic breathing exercises

Box 2. Pulse Oximetry Monitoring Considerations

1. Movement: Motion[50] and weight bearing can interfere with the signal transmitted to the sensor. Newer, motion-sensitive, technology has shown to be more accurate than traditional technology during motion.[51]

2. Probe location: Placing the probe on the 3rd or 4th fingers has been shown to produce more accurate readings than the index finger.[50] Placing the probe on the finger is generally more accurate than the earlobe.[52]
   - A forehead probe may be one of the most accurate ways of measuring pulse oximetry due to placement onto a central location of the body and the ability to bypass temperature, circulatory, and neurological factors affecting the peripheral digits and earlobes.
   - Dirt, fingernail polish, blood etc. can block the sensor light path. The sensor is also calibrated to account for the tissue/cartilage in the ear when using an ear probe. However, the pulse oximeter assumes nothing else, ie, dirt, is blocking the light passing from the emitter to the detector.

3. Probe size and type:
   - Use a pediatric size probe for children and an adult size probe for adults.
   - Use a forehead probe if finger and earlobe appear to be inaccurate according to clinical symptoms.

4. Sensor positioning:
   - If the emitter and detector sensors (especially of a disposable probe) are not in proper alignment, falsely low readings of oxygen saturation can occur.[53]

5. "Probe off" false reading: The probe is actually off the finger or ear but a reading is given by the oximeter.

6. Low perfusion and/or dysrhythmias:
   - Weak signal strength occurs in patients with poor perfusion therefore inaccurate readings may occur.[52]
   - Weak signal strength occurs in patients with atrial fibrillation (due to the irregular pulse rate) and inaccurate readings may occur.

- Vital signs including heart rate and blood pressure before, during, and after the prescribed activity

Precautions should be taken to educate patients regarding the importance of not smoking while utilizing supplemental oxygen as this is a fire risk and smoking also has been shown to offset treatment benefit of supplemental oxygen.[47,48]

Supplemental Oxygen Delivery Devices

The fraction of inspired oxygen (FiO_2) represents the percentage of oxygen in atmospheric air. Normal room air has a FiO_2 of 0.21 at sea level. The FiO_2 may be increased by increasing the flow rate of supplemental oxygen from an oxygen source. Alternatively, the FiO_2 may also be increased by altering the supplemental oxygen delivery device while keeping the oxygen flow rate constant. It is important for the physical therapist to understand that both flow rate and delivery device may be manipulated to change the FiO_2. Both device used and flow rate must be documented to allow clear communication to other practitioners (eg, 2 l/min via nasal cannulae).

Determination of the FiO_2 for patients using nasal cannulae may be estimated by inserting oxygen flow rate in the equation below. The actual FiO_2 received by the patient may vary quite a bit depending on breathing pattern (eg, nose vs mouth breathing).

FiO_2 = flow rate in liters per minute (l/min) x 4 + 0.20 (approximating room air value)

For example, if a patient is receiving 4 l/min via nasal cannulae, the FiO_2 is approximately 0.36.

In addition to estimating FiO_2, it is helpful to be able to calculate how long an oxygen supply will last at a given flow rate. The following formula may be used with the typical "e-cylinder" (29 inches high by 5 inches diameter) portable compressed gas tanks only.

$$\text{Time to empty} = \frac{\text{lbs/sp in X .28}}{\text{flow rate (l/min)}}$$

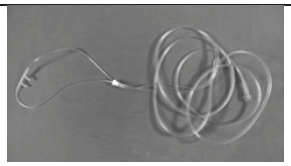
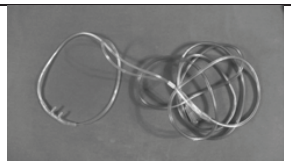
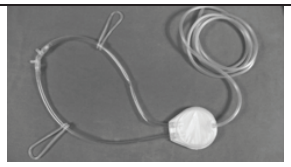
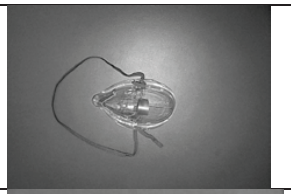
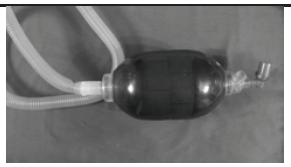
For example, if a patient is on 4 l/min via nasal cannulae, and the psi is 1000, the tank will be empty in approximately 70 minutes. It is suggested to subtract 200 psi off the reading of the tank as a safeguard to ensure some oxygen remains in the tank, given the error of approximation.

For more information on specific supplemental oxygen delivery devices, tubing, etc, please see Table 2 and Box 3.

Legal Issues Regarding Physical Therapist Administration of Supplemental Oxygen

Supplemental oxygen for medical conditions is regulated as a drug by the Food and Drug Administration and requires a prescription for its use. The supplemental oxygen prescription should be written based upon SpO_2 and not flow rate (l/min). Therefore, physical therapists should always check standing orders or a patient's specific order. Should a physical therapist need to request a revision

Table 2. Typical Oxygen Delivery Service

Device Name	Picture of Device	General Information	Approximate FiO_2
Nasal Cannula (NC)		Delivers flows from 0.25 to 6 l/min Generally recommended low flow NCs **not** used for flows > 6 l/min due to patient discomfort	O_2 Tank Flow: Approximate FiO_2 1 L/min 0.24 2 L/min 0.28 3 L/min 0.32 4 L/min 0.36 5 L/min 0.40 6 L/min 0.44
High Flow Nasal Cannula		Best for patients needing > 6 l/min NC More comfortable, can eat/drink/talk easier than with mask	Highest % O_2 is up to 0.75 FiO_2 at 15 l/min
Oxymizer (Reservoir can also be incorporated into tubing sitting below the nasal prongs)		Specialized NC with O_2 reservoir that conserves O_2 Uses 25-75% less O_2 (the less O_2 needed by the patient, the higher savings of O_2) Good way to deliver O_2 at home.	O_2 Tank Flow: Approximate FiO_2 1 l/min 0.28 2 l/min 0.32 4 l/min 0.41 8 l/min 0.64 12 l/min 0.82
Simple Face Mask		Covers mouth and nose, useful for patients unable to breathe through nose	O_2 Tank Flow: Approximate FiO_2 6-10 l/min 0.35-0.50 (can vary)
Venturi System		O_2 system providing more specific O_2 concentration than other devices Easy system for mobilizing patients Can provide O_2 via face mask or tracheostomy tube	O_2 Tank Flow: Approximate FiO_2 Turn dial and provide O_2 flow as stated on dial for needed FiO_2 0.24-0.50
Non-rebreather Mask		Mask with O_2 reservoir (bag) providing higher FiO_2 Advantage – requires a lower flow of O_2 from the tank for the FiO_2 needed	O_2 Tank Flow: Approximate FiO_2 6 l/min 0.60 7 l/min 0.70 8-10 l/min 0.80+
Ambu Bag		Can be used to manually ventilate patients during ambulation when a portable ventilator is not available, give supplemental O_2 for suctioning etc. For mobility, a tracheostomy swivel connector with expandable tubing should be used to prevent extubation.	Up to 1.00 FiO_2

Box 3. Methods of Supplemental Oxygen Delivery

Continuous flow oxygen regulators: Oxygen flow is continuous throughout the entire respiratory cycle of inspiration and exhalation. This category is typically found on "e-cylinders" commonly used in hospital settings as well as lighter weight units for portable use. This type of regulator is recommended for patients who require higher flow rates of supplemental oxygen and use high flow oxygen delivery devices (for flow rates of 6 -15 l/min). There is no delay in supplemental oxygen getting to patient as it is provided continuously, most often through nasal cannulae. As long as patient breathes in through the nose, the patient derives the benefit of the supplemental oxygen.

On-demand oxygen regulators (pulsed): On-demand oxygen devices deliver a bolus of supplemental oxygen, usually upon inhalation through the nose. In comparison to continuous flow regulators, the duration of supplemental oxygen provided in a similar size tank can be increased. The device senses the start of inhalation (via a double lumen nasal cannula) and immediately gives a short pulse of supplemental oxygen. One lumen of the oxygen tubing is connected to the oxygen flow portal and the other lumen is connected to a sensing trigger portal. The sensitivity of this device is impaired if there is nasal congestion, mouth breathing, or if the patient cannot produce adequate inspiratory pressures. Most of these systems are battery driven.

Oxygen concentrator: An oxygen concentrator draws in room air, passes the air through a special filter, and collects only the oxygen into a reservoir. The concentrator has limited storage so essentially all of the oxygen is released into the tubing to the patient. Home concentrators are heavy (about 50 pounds) and are usually on wheels so that they can be moved from room to room. A concentrator requires an electrical outlet and produces a relatively loud noise, resulting in many patients choosing to keep their concentrator in separate room. Most oxygen concentrators deliver a maximum flow rate of 5 l/min. Portable oxygen concentrators are available that can be wheeled by the patient. These weigh approximately 10 pounds and are either battery or electrically powered. Maximal continuous flow rates are typically 2-3 l/min; whereas pulsed flow rates may go to a maximum of 5-6 l/min. In general, a smaller portable concentrator is only capable of lower maximum flow rate.

Liquid oxygen: When in liquid form, oxygen takes up less space and is stored in specially designed reservoir tanks. Small liquid portable oxygen tanks are filled from these containers. There is a tendency for liquid oxygen to leak out of a portable system when sitting for a period of time and for reservoir and portable tanks to freeze at low ambient temperatures and when used at higher flow rates.

Compressed gas cylinders: Compressed gas cylinders are the oldest and most reliable type of portable delivery system. Oxygen is compressed into various sized metal cylinders under high pressure. In recent years, cylinders have been manufactured from aluminum rather than steel; allowing for easier portability. Larger cylinders may deliver from 0.25 to 25 l/min through a conventional regulator.

in the written prescription, the recommendation is that it should be written: "maintain $SpO_2 \geq 90\%$" (or other value, depending on diagnosis).

Physical therapists working in any practice setting should be concerned about the legal implications of working with supplemental oxygen, including its titration, since supplemental oxygen is considered a drug. In a review of all legal practice acts, the APTA's Policy and Payment Department has not found any limitations on physical therapists in use of, or titration of, supplemental oxygen in any state.[46] It appears most physical therapy practice acts and physical therapy board regulations are silent on the administration of supplemental oxygen. However, some state/jurisdiction licensing authorities have provided official interpretive opinions/statements on this issue. Physical therapists should check with state/jurisdiction licensing authorities to determine if there is an official statement or opinion regarding the administration of supplemental oxygen.

The state of Connecticut has made legislative changes on the use of supplemental oxygen in hospitals that went into effect in October 2010. The legislation requires all individuals who handle supplemental oxygen in any way to be trained in its use. The law allows a hospital to train certain licensed and certified staff to connect or disconnect supplemental oxygen; transport a portable supplemental oxygen source; connect, disconnect, or adjust a mask or nasal cannulae and adjust the flow rate to carry out a medical order.

The APTA's position statement regarding pharmacology (HOD P06-04-14-14 Program 32) [Initial HOD 06-89-43-89] discusses medications in the provision of physical therapy services. It is felt that supplemental oxygen management falls within the "Medications" section which states:

- Physical therapist patient/client management integrates an understanding of a patient's/client's prescription and nonprescription medication regimen with consideration of its impact upon health, impairments, functional limitations, and disabilities.
- The administration and storage of medications used for physical therapy interventions is also a component of patient/client management and thus within the scope of physical therapist practice.
- Physical therapy interventions that may require the concomitant use of medications include, but are not limited to, agents that promote integumentary repair and/or protection; facilitate airway clearance and/or ventilation and respiration; facilitate adequate circulation and/or metabolism; and facilitate functional movement.[49]

In addition to this APTA policy, the *Guide to Physical Therapist Practice*[45] includes the use of supportive devices and supplemental oxygen under the heading of "Prescription and Devices Used by Physical Therapists."

SUMMARY AND RECOMMENDATIONS ON THE USE OF SUPPLEMENTAL OXYGEN THERAPY BY PHYSICAL THERAPISTS

1. Supplemental oxygen is a drug and requires a prescription for use. When considering titration of supplemental oxygen with activity, an order should be in place written "Keep SpO_2 ≥ ___% "(typically 88-90). This is the legal prescription that allows titration of supplemental oxygen in any practice setting.
2. Continuous supplemental oxygen therapy is indicated when PaO_2 ≤ 55 mm Hg or SpO_2 ≤ 88% or in presence of cor pulmonale, PaO_2 55-59 mm Hg or SaO_2 ≤ 89%, with documented right atrial enlargement, hematocrit > 55%, or congestive heart failure. Supplemental oxygen delivery should be set to keep SpO_2 ≥ 90% (or per MD order) at rest, and should be titrated by a minimum of 1 l/min for sleep, air travel, or activity.[7]
3. Nocturnal supplemental oxygen therapy is indicated when oxygen desaturation occurs during sleep (PaO_2 falls below 55 mm Hg or SpO_2 < 90%) despite optimal additional therapy including continuous positive airway pressure or bilevel positive airway pressure. Individuals requiring this supplemental oxygen should be assessed during sleep with pulse oximetry.
4. Intermittent supplemental oxygen therapy should be provided to improve quality of life and functional activity for those who experience oxygen desaturation during activity or exercise (when the PaO_2 ≥ 60 mm Hg or SpO_2 ≥ 90% at rest but the patient desaturates during activity).[22] It is recommended to evaluate vital signs and incorporate breathing exercises when desaturation occurs with activity, in addition to titrating supplemental oxygen. Intermittent supplemental oxygen therapy has been found to be useful in rehabilitation programs for those with chronic lung disease, those awaiting lung surgery, etc., to improve level of fitness and therefore supplemental oxygen should be an adjunct to rehabilitation.[22]
5. Supplemental oxygen should be initiated with a prescription and titrated to the activity by assessing vital signs, symptoms, and breathing. Assessment of the adequacy of relief of hypoxemia should be performed with pulse oximetry as well as improvement in level of dyspnea and/or improvement in exercise tolerance. Patients should be reassessed 1 to 2 months after starting continuous supplemental oxygen or nocturnal supplemental oxygen with assessment of resting as well as activity SpO_2. Patients may have been prescribed supplemental oxygen while acutely ill, however, with improvement in physical condition may not need the supplemental oxygen prescribed. Assessment of need for oxygen should be performed during every treatment session in these individuals.
6. Retention of carbon dioxide should not be a contraindication to supplemental oxygen use or supplemental oxygen titration. All individuals should be assessed for supplemental oxygen needs at rest and with activity based upon SpO_2 and symptoms. In individuals who have demonstrated oxygen desaturation with activity but do not demonstrate an improvement in SpO_2 despite appropriate breathing exercises and appropriate utilization of supplemental oxygen delivery devices, supplemental oxygen titration with activity may not be indicated.
7. Recommendations for the use of supplemental oxygen to optimize the functional abilities of individuals:
    - Assessment of the need for supplemental oxygen at rest and with activity, including the appropriate supplemental oxygen delivery devices
    - Instruction of patients in use of appropriate breathing exercises to optimize supplemental oxygen utilization and decrease breathlessness
    - Appropriate titration of supplemental oxygen with activity
    - Instruction of patients in titration of supplemental oxygen with activity including specific amount of titration with each activity
    - Appropriate exercise prescription with adjustment of supplemental oxygen to increase functional performance
    - Instruction in use of supplemental oxygen with air travel (see Box 4)

CONCLUSION

The use of supplemental oxygen is an important component of disease management in many patients who demonstrate hypoxemia at rest and/or with activity and a need exists for recommendations for use of supplemental oxygen in the clinical setting. Physical therapists are often required to utilize supplemental oxygen with patients in diverse settings but currently no national recommendations, guidelines, or position statements exist to guide physical therapy practice. This document provides guidelines for physical therapists based upon an extensive search of evidence regarding assessment and management of supplemental oxygen for patients with cardiopulmonary diseases. The guidelines describe the physical therapist's role with titration of supplemental oxygen ensuring safety with activity, providing appropriate exercise prescriptions to increase functional performance, and instructing patients in use of appropriate breathing exercises to optimize supplemental oxygen and decrease breathlessness.

Box 4. Need for Supplemental Oxygen During Air Travel[24,25]

Commercial aircraft operate at altitudes of up to 12,500 meters (41,000 feet), with the plane's interior pressurized to 2100 – 2400 meters (7000-8000 feet). At this level of pressurization, the alveolar PaO_2 for healthy individuals decreases from 103 mmHg to 64 mmHg and oxygen saturation declines from 97% to 93%. As a general rule, supplemental oxygen is unlikely to be required if a patient's resting oxygen saturation is 95% or higher, and likely to be required if oxygen saturation is 88% or lower. Patients with oxygen saturation values between these levels might require individual assessment regarding need for supplemental oxygen.

Before flying, patients should ideally be clinically stable. Patients recovering from an acute exacerbation of their pulmonary disease are particularly at risk for desaturation during air travel. Those already on long-term supplemental oxygen therapy typically need an increase in flow rate of 1–2 l/min during flight. Careful consideration should be given to patients with any co-morbidities that may impair delivery of oxygen to the tissues (eg, cardiac impairment, anemia). Exertion during flight will exacerbate hypoxemia.

The American Thoracic Society currently recommends that PaO_2 during air travel should be maintained at more than 50 mmHg.[54] All patients with a PaO_2 less than 70 mmHg at rest at ground level should receive supplemental oxygen during air travel.

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