METHOD FOR ENHANCING TRAINING EFFECTIVENESS

The present invention provides methods for exercise training to improve exercise performance in an individual using low-resistance positive airway pressure and specialized gas mixtures during or immediately after exercise. The methods include wearing an interface, i.e. mask, connected by a tubing circuit to a positive airway pressure (PAP) assist ventilator device. The PAP device is connected to flexible tubing connected through a pressure regulator to a liquid gas source which supplies the gas mixture. Optionally, a gas impermeable bag or vessel is connected to both the PAP device and the liquid gas source to receive, store and condition gas(es) that is delivered to the PAP device from the liquid gas source. The methods also include simulating high altitude exercise training by using the PAP device with a hypoxic level of oxygen in the gas mixture. The methods of the present invention reallocate oxygen between muscle groups, improve oxygen delivery to muscles, improve oxygen utilization by muscles reduce fatigue, lessen episodes of dyspnea, improve conditioning levels and overall improve training to extreme levels of performance.
METHOD FOR ENHANCING TRAINING EFFECTIVENESS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation-in-part application and claims priority to U.S. patent application Ser. No. 13/154,933 filed Jun. 7, 2011 entitled METHOD FOR ENHANCING TRAINING EFFECTIVENESS.

FIELD OF THE INVENTION

[0002] The present invention relates to exercise training and, in particular, a method for reallocating oxygen consumption load between various muscle groups, and organ systems within the human body to improve exercise effectiveness, more particularly through the use of, optionally multiple, oxygen load shifting strategies during the course of training to extreme exertion approaching the safe limits of human exertion and/or performance.

BACKGROUND OF THE INVENTION

[0003] Most commonly oxygen supplementation is used in medicine, which often employs helium and oxygen gas mixtures. Oxygen supplementation involving the use of pure oxygen is routinely used in sports, typically after an individual has undergone physical exertion during a competitive event to hasten recovery after stress, for example, by a football player after running a long distance for a touchdown. Research has also been done in the use of hypoxic atmospheres in training environments. Likewise, some scuba diving techniques may involve the breathing of helium and oxygen gas mixtures.

SUMMARY OF THE INVENTION

[0004] In accordance with the invention, a person undergoing exercise training enhances exercise performance by reallocating the distribution of inspired oxygen, in order to optimize the amount of oxygen delivered to exercising muscles while decreasing the amount of oxygen used by respiratory muscles.

[0005] In accordance with the invention, it is recognized that the amount of oxygen absorbed by the lungs of a healthy individual during breathing is basically unaffected by the purity of oxygen gas inhaled. Thus, the routine use of oxygen in sports may be of little value. Reallocation of oxygen between muscle groups is the inventive approach. Healthy lungs absorb substantially the same amount of oxygen whether the source of oxygen is air, which contains about 21% oxygen, or pure oxygen, that is, 100% oxygen. Therefore, increasing the percentage of oxygen that is administered to an individual does not substantially affect how much oxygen is getting to the exercising muscles.

[0006] In accordance with the invention, it is recognized that what does affect the amount of oxygen delivered to exercising muscles is the density of air a person breaths while exercising: lower density oxygen-containing air is transported more easily through the airways of the lungs to the gas-permeable cells, i.e. alveoli, of the lungs than higher density oxygen-containing air. One way to lower the density of oxygen-containing air is to mix helium gas with oxygen or oxygen-containing air. The use of a mixture of helium gas and oxygen gas (HeO2), also referred to as helium, has been reported to enhance the ability of noninvasive ventilation to reduce the effort of breathing and to improve gas exchange in patients suffering from chronic obstructive pulmonary disease (Jaber, S. et al., Noninvase Ventilation with Helium-Oxygen in Acute Exacerbations of Chronic Obstructive Pulmonary Disease, Am. J. Respir. Crit. Care Med., Vol. 161, pp. 1191-1200, 2000). Hence, lowering the density of oxygen-containing air that an individual breaths during exercise training by using a mixture of HeO2 gas, reduces the work expended by respiratory muscles, and thus more oxygen is available to the exercising muscles.

[0007] Currently, there exist a wide variety of noninvasive respiratory devices. See, for example, U.S. Patent Application No. 2006/0095300, which discloses a breathing apparatus comprised of a semi-closed breathing circuit which includes a gas reservoir into which some exhaled gas is directed and from which some inhaled gas is drawn wherein a portion of the gas reservoir is in fluid communication with an external environment. This device, however, does not provide for low resistance positive airway pressure ventilation to train exercising muscles.

[0008] The use of pure oxygen in sports to hasten recovery after exertion is of questionable value. Moreover, such devices and their current techniques of use do little or nothing to increase the effectiveness of training, despite their widespread use. A need exists, therefore, for a method to improve exercise training and performance by decreasing the work expended by respiratory muscles and increasing oxygen delivery to exercising muscles during and immediately after exercise training.

[0009] The present invention fulfills this need by providing methods of exercise training to improve exercise performance in an individual comprised of breathing a low-density gas comprised of a mixture of helium and oxygen (HeO2) gas during and/or immediately after exercise training. The methods of the present invention are suited for healthy individuals who wish to improve their exercise performance during exercise, but can be used to improve exercise performance (for example during a rehabilitation program) in patients suffering from various types of cardiovascular and pulmonary diseases including, but not limited to, chronic obstructive pulmonary disease (COPD) and asthma.

[0010] In one aspect of the invention, there is provided a method of exercise training to improve exercise performance in an individual comprising breathing a low-density gas comprised of a mixture of HeO2 gas by having an individual wear an interface which delivers the HeO2 gas mixture to the individual. The interface is connected via a tubing circuit to a positive airway pressure (PAP) assist ventilator device that is connected to flexible tubing connected through a pressure regulator to a liquid gas source which supplies the HeO2 gas mixture to the PAP device. Both the interface and the tubing circuit comprise a breathing circuit.

[0011] In an embodiment, the individual breathes the mixture of HeO2 gas during exercise training in order to reduce the work of breathing by the individual. In another embodiment, the individual breathes the mixture of HeO2 gas immediately after exercise training to reduce recovery time from the exercise training and allow further training. In an embodiment, the individual breathes the mixture of HeO2 gas during exercise training in order to reduce the work of breathing by the individual. In yet another most preferred embodiment, the individual breathes the mixture of HeO2 gas during and immediately after exercise training to allow for extreme training.
The present invention provides methods of training to improve athletic performance in an individual. More particularly, in accordance with the invention, the individual breaths a low-density gas comprised of a mixture of helium and oxygen (HeO₂₂) during and/or immediately after exercise training. The methods of the present invention are suited for healthy individuals who wish to improve their exercise performance during exercise training.

As used herein, except where defined otherwise, the phrase “exercising muscles” is meant to refer to those muscles involved in athletic training other than respiratory muscles required for breathing.

The term “inspiration” is interchangeable with the term “inhalation;” the term “expiration” is interchangeable with the term “exhalation.”

In an embodiment of the present invention, as shown in FIG. 1, there is provided a method of exercise training to improve exercise performance in an individual comprising breathing a low-density gas comprised of a mixture of helium and oxygen by having the individual wear an interface which delivers the HeO₂₂ gas mixture to the individual. The interface is connected via a tube circuit connected through a press regulator to a liquid gas source which supplies the HeO₂₂ gas mixture to the PAP device.

According to the invention, it has been recognized that during athletic training, and in particular competitive athletic training, the objective is to exercise certain muscle groups associated with the sport for which the individual is training. For example, in the case of track, the muscles of the legs and thighs and other associated muscle groups need to be developed to increase their performance. Performance development has as its objectives both the development of strength and endurance in the selected muscle groups.

In order for this to be achieved, these muscle groups have to perform at extreme levels of performance. Generally, for the body of the athlete, athletes who train to the point where their muscles are performing regularly at levels higher than their competitors will outperform competitors during a competition. In order to reach those higher levels of performance, the muscles must receive the raw materials which fueled the performance, namely, nutrition and oxygen. Nutrition regimens, including supplementation, are well developed and are not the objective of the present invention. It is contemplated that conventional nutritional regimens may be employed with the inventive method.

However, the inventive methods are concerned with techniques for increasing the amount of oxygen available during training to a muscle group to be trained. More particularly, the invention contemplates the shifting of oxygen demand from muscles which are not the objective of a particular exercise to muscles which are the objective of the exercise, accordingly, allowing more extreme development of the muscles which are the objective of the exercise.

In principle, an athlete in training may spend time pushing the extreme development and performance of a first group of muscles at one time, and pushing the extreme development and performance of another group of muscles at another time, thus bringing a large group for muscles to an extreme point of development and performance.
In accordance with the present invention, oxygen demand fulfillment is shifted from the muscles involved in breathing to other muscles by reducing the effort, or work of breathing. This means that more oxygen is available and therefore exercise and training can be taken to a more extreme level of high performance. Generally, it is noted that the density of air or other gaseous fluid being breathed by an individual is the cause of significant viscous resistance. This is because as the air travels through the upper airways and trachea into the lungs and ultimately into the alveoli, where gas exchange and oxygenation occurs, there are multiple branch points in the airways, and a reduction in the cross-sectional airway size. The airways, or carrying passages of the lungs, are extremely small at the point where the blood is oxygenated, and have gone through multiple branch points, or generations. At an airway branch point, eddies occur in the air or gas flow resulting in turbulence. There is an increased work associated with the movement of turbulent (as opposed to non-turbulent or laminar-flowing) gas through the respiratory system. The degree to which an inhaled gas or air develops turbulence at airway branch points is proportional to the density of the gas, that is to say, the lower the density of the gas, the less turbulence in the gas, and less work associated with its movement through the airways. Resistance to a gas as it moves through the airways is also proportional to the density of the inspired gas, and the cross-sectional size of the airways. Because they are so small, and the respiratory rate and ventilation is so high during exercise, a very significant viscous resistance is encountered in the airways, forcing the muscles involved in breathing to do much work, and, consequently, consume much oxygen.

In accordance with the invention, this load, and the resulting work associated with it, is reduced through the use of low density, low viscosity breathing gases during exercise and periods of extreme physical exertion.

While the primary objective of the present invention is to use a low viscosity helium gas mixture for the purpose of reducing oxygen demand by the muscles involved in breathing, in principle the invention also contemplates the use of a mask with small input air passages, which provide an increased resistance to breathing, communicating with the ambient air, or other breathing gas, in order to increase the amount of work needed to breathe, for the purpose of developing the muscles associated with breathing during a different part of the training regimen, which has the specific objective of increasing the performance of breathing muscles by pushing them to extremes not normally encountered during routine exercise. However, it is noted that depending upon the athletic event being trained for, enhanced performance of the lungs may not be an issue and such a part of the training regimen would not be necessary.

Finally, the possibility also exists to use a high viscosity breathing gas mixture to increase the work being done by the muscles which enable the lungs to breathe.

Returning to the embodiment of the invention involving the reduction of the workload associated with breathing, the HeO₂ gas mixture provided in accordance with the present invention provides a fractional inspired oxygen (\(\text{FiO}_2\)) of about 21% and a corresponding fractional inspired helium (\(\text{FiHe}\)) of about 79%. A lower \(\text{FiO}_2\) may be used in the breathing gas mixture, when the device is being used as part of a hypoxic training, or altitude simulation regimen.

The interface 12 is comprised of a mask worn by the individual 10. The mask may be a full-face mask, a face shield style mask, a nasal style mask, an oro-nasal style mask, a mouth-only style mask, a high flow nasal cannula or any other style mask capable of delivering gas and pressure from the breathing circuit 24 to the individual 10. The mask may have a fixed or a variable leak function in which the mask vents exhaled breath into the atmosphere.

In accordance with the invention it is also contemplated that the mask may be battery powered or externally powered and/or may include a transmitter for transmitting data between the mask and the PAP device 16 and the interface 12. The breathing circuit 14 is gas impermeable and may contain internal wires for transmitting electrical power and/or data between the PAP device 16 and the interface 12.

In an embodiment, an individual 10 breathes the mixture of HeO₂ gas during exercise training in order to reduce the work of breathing by the individual 10. In another embodiment, an individual 10 breathes the mixture of HeO₂ gas immediately after exercise training to reduce recovery time from the exercise training.

The liquid gas source 22 may be either an external high capacity liquid gas storage tank or a portable liquid gas canister.

The HeO₂ gas mixture gas may be delivered into the breathing circuit 24 in either a closed configuration or an open configuration. In the closed configuration, the HeO₂ gas mixture is supplied directly to the PAP device 16 via flexible tubing 18 connected to a liquid gas source 22. In an open configuration, the PAP device 16 draws air from the surrounding environment at ambient atmospheric pressure into the breathing circuit 24. The HeO₂ gas mixture may be delivered into the tubing circuit 14, into the interface 12, or into both the tubing circuit 14 and the interface 12.

The interface 12 or the tubing circuit 14 may contain an end tidal carbon dioxide (\(\text{CO}_2\)) sensor safety override system capable of measuring \(\text{CO}_2\) levels in the breathing circuit 24. When unsafe levels of \(\text{CO}_2\) are detected, the \(\text{CO}_2\) sensor alters the PAP device 16 by altering system leak levels to allow for greater \(\text{CO}_2\) escape from the breathing circuit 24, by changing pressure or flow levels, or by terminating function of the PAP device 16.

The PAP device 16 may contain an oxygen (\(\text{O}_2\)) sensor system capable of measuring the concentration of \(\text{O}_2\) in the breathing circuit 24 and communicating this information to an electronics system onboard the PAP device 16.

The PAP device 16 may contain internal flow sensors and pressure sensors capable of sensing variable inspiratory rates, expiratory rates and leak rates within the breathing circuit 24.

The PAP device 16 may have an internal electronic algorithm which can vary the pressure delivered within the breathing circuit 24 in order to maintain a desired pressure, or a desired end tidal \(\text{CO}_2\) level.

The PAP device 16 is capable of generating either continuous level or bi-level modes of respiratory pressures within the breathing circuit 24. In a continuous mode, also referred to as continuous positive airway pressure (CPAP), the PAP device 16 generates a fixed respiratory pressure which ranges from about 4 cm to about 30 cm of H₂O pressure. In a bi-level mode, also referred to as bi-level positive airway pressure (BIPAP), the PAP device 16 generates a bi-level respiratory pressure in which the PAP device 16
cycles between a higher inspiratory pressure and a lower expiratory pressure. Both the inspiratory pressure and the expiratory pressure can range from about 4 cm to about 30 cm of H₂O pressure (with the inspiratory pressure having a higher value than the expiratory pressure). The PAP device may also contain an internal algorithm to sense breathing circuit flow and leak rates and adjust PAP device flow to maintain airway pressures in the desired range.

In an embodiment, the PAP device 16 is powered by a portable battery power source and the liquid gas source 22 is a portable liquid gas canister, making the entire low-resistance positive airway system portable and wearable by an individual.

The PAP device 16 may contain internal software which provides wireless capability for wireless communication, device control and transfer of information from the PAP device 16.

In another aspect of the invention, also referring to FIG. 1, there is provided a method of simulating high altitude exercise training in an individual 10 comprising breathing a low-density gas comprised of a mixture of helium gas and a hypoxic level of oxygen gas (He-hypO₂) by having an individual 10 wear an interface 12 as described above which delivers the He-hypO₂ gas mixture to the individual 10.

The interface 12 is connected via a tubing circuit 14 to a positive airway pressure (PAP) assist ventilator device 16 as described above, which is connected to flexible tubing 18 connected through a pressure regulator 20 to a liquid gas source 22 which supplies the He-hypO₂ gas mixture to the PAP device 16.

The He-hypO₂ gas mixture provides an FiO₂ ranging from about 12% to about 20% and a corresponding FiHe ranging from about 88% to about 80%.

The He-hypO₂ gas mixture may be delivered into the breathing circuit 24 either in a closed configuration or an open configuration. In the closed configuration, the He-hypO₂ gas mixture is supplied directly to the PAP device 16 via flexible tubing 18 which is connected to a liquid gas source 22 such as an external high capacity liquid gas storage tank. In an open configuration, the PAP device 16 draws air from the surrounding environment at ambient atmospheric pressure into the breathing circuit 24 and helium gas is delivered into the breathing circuit 24 to dilute the FiO₂. The helium gas can be delivered into the tubing circuit 14, the interface 12 or into both the tubing circuit 14 and the interface 12. The helium gas is delivered to the interface 12 via flexible tubing 18 connected to a liquid gas source 22 such as a liquid helium gas supply. The flow rate of the helium gas is controlled by a pressure regulator 20 connected to the liquid helium gas supply via the flexible tubing 18. The pressure regulator 20 may be controlled by an electronics system of the PAP device 16. The flow rate of the helium gas is varied according to an individual’s minute ventilation rate. The flow rate of the helium gas may also be controlled by the oxygen sensor system, pressure sensors, flow sensors or end-tidal capnographic sensors or other device safety sensors.

The PAP device 16 may contain a pulse oximetry safety override system consisting of a pulse oximeter probe (not shown) worn by the individual 10 during exercise training. The pulse oximeter probe is capable of transmitting data either through wires or wirelessly from the oximeter to the PAP device 16 electronics system, in which a safety protocol

The gas impermeable bag 26 serves as a reservoir for gas or gasses to which the PAP device 16 can draw upon. This is accomplished by the gas impermeable bag 26 receiving, storing and conditioning the gas or gasses that are delivered to the PAP device 16 from the liquid gas source(s) 22. The gas impermeable bag 26 may contain a pressure sensor 30 which communicates with the pressure regulator 20 on the liquid gas source 22 and/or with the PAP device 16 either directly or through an external electronics computer system in order to regulate gas flow into the gas impermeable bag 26. FIG. 3 shows an embodiment of the invention having a gas conditioning and storage reservoir 26 containing a non-diffusing gas bag or any suitable type of gas-impermeable reservoir. The gas conditioning and storage reservoir 26 may be incorporated into an external housing 28 which contains therein the PAP device 16. The volume of the gas impermeable bag can range from about 5 liters to about 170 liters or more. The reservoir 26 can be fabricated from metal or plastic and can be plastic- or metal-lined, having a space defined therein filled with air. The external housing 28 may have casters 34 to attach the housing 28 to a fixed position.

In an embodiment, the non-diffusing gas collection bag may be fabricated from a multi-layer thermoplastic laminate having a foil diffusion barrier.

In another embodiment, a fixed volume metal or gas impermeable (or semi-permeable) plastic reservoir may be used for gas storage and conditioning prior to pressurization by the PAP device and entry into the breathing circuit.

The methods of the present invention improve exercise performance by reducing the work expended by respiratory muscles of the exercising individual. With reduced expenditure of energy by the respiratory muscles, the individual more efficiently clears CO₂ from the lungs produced by exercising muscles and body tissues and provides more O₂ to the exercising muscles and other body tissues. The overall effect is to reduce the work of breathing caused by elevated respiratory system workloads experienced with training for competitive activities. Thus, reducing the work of breathing during training using the methods of the present invention allows an individual to redirect metabolic energy from the respiratory muscles to the muscles of the individual which are undergoing training. This allows the individual to achieve higher performance levels due to increased metabolic efficiency. Regular use of the methods of the present invention during and optionally immediately after exercise training leads to more rapid and higher levels of physical conditioning than could be achieved with traditional exercise training methods, and when used immediately after exercise allow for a more rapid recovery time from extreme physical exercise, allowing an athlete or person suffering from cardiovascular or lung disease to resume exercise or other type of physical activity in a shorter period of time than would be possible without device use.
At the same time, as alluded to above, in accordance with the invention, a positive airway pressure is used in feeding the helium/oxygen mixture to the individual undergoing training. This further reduces the oxygen load associated with breathing during extreme exercise training by reducing upper airway resistance, providing an inspiratory flow assist, and reducing dynamic airway collapse during forced exhalation as occurs in exercise. Thus, the methods of the present invention reduce the work of breathing by an individual in two ways: breathing a HeO₂ gas mixture during or immediately after exercise training and the use of positive airway pressure during or immediately after exercise training, as discussed below.

A mixture of HeO₂ gas has a lower resistance through the airways of an individual as compared to atmospheric air. This is due to the substitution of helium gas for nitrogen, and other higher density gasses normally found in atmospheric air. Helium gas has a lower density and viscosity, and thus a lower resistance through airway passages, than nitrogen gas. The low-resistance HeO₂ gas mixture thus reduces the viscosity associated with turbulent and non-turbulent gas flow in large airway passages, at airway branch points and in irregularly-shaped upper airway passages of an individual. This in turn reduces the force required to generate a given inspiratory or expiratory flow rate by an individual.

The positive airway pressure used by the methods of the present invention provides a positive pressure assist to an individual during inhalation, which reduces the resistive work required to transport gas through the irregularly-shaped upper airway passages of an individual. The reduced work encountered by the individual allows the individual to generate higher tidal volumes with a smaller work load. The positive end expiratory pressure achieved by using positive airway pressure prevents dynamic airway collapse during forced exhalation which allows for more efficient clearance of exhaled gas during exercise training. The interface used in the methods of the present invention contains a leak system designed to use the positive pressure in the breathing circuit to wash exhaled CO₂ from an individual’s dead space. This further improves the ventilatory efficiency of the individual’s respiratory system. With the use of a low-resistance positive airway pressure system according to the methods of the present invention, an individual is able to expel more CO₂ with each breath, which allows for lower respiratory rates and higher tidal volumes during and immediately after exercise training.

Thus, the methods of the present invention provide unexpected benefits to an individual that is undergoing exercise training or immediately recovering from exercise training such as (1) reduced work of breathing; (2) reduced fatigue levels; (3) less dyspnea (shortness of breath); (4) improved conditioning levels with repeated use compared to traditional exercise regimens; (5) improved recovery times after exercise; and (6) overall improved exercise performance.

If, an optionally hypoxic, mixture of helium and oxygen is used, the methods of the present invention provide the additional advantage of simulating altitude training and accordingly also provide unexpected benefits to an individual by easily simulating a high altitude, low O₂ environment at sea level (or at any altitude). This stimulation of the bone marrow to produce a greater number of red blood cells, and causes changes in muscle and blood cell metabolism to more efficiently transport and utilize oxygen on a cellular level, allowing an individual to effectively acclimate to exercise in a low O₂ environment. These changes metabolic changes associated with device usage will further improve exercise capacity at the extreme workloads associated with athletic competition.

More importantly, such hypoxic conditioning, in accordance with the invention results in increasing the number and altering the chemical composition of the red blood cells thus increasing the oxygen carrying capacity and delivery ability of the blood. This enables yet further extremes in training and conditioning resulting in further enhanced athletic performance. In accordance with the preferred embodiment, it is believed that the combination of hypoxic and low viscosity gases provides a multiple event which enables athletes to achieve extreme levels in the development of strength and endurance, and thus enable extreme performance.

Regular exposure to exercise in a hypoxic environment produces physiological changes in an individual which augments O₂ delivery, O₂ extraction from red blood cells and O₂ utilization in body tissues.

It is noted that in accordance with the present invention, training may be carried beyond conventional levels, and due to the same, increased performance can be achieved during athletic competition. In this regard, it is contemplated that trainees, as in conventional training regimens, generally push athletes to high levels of performance, taking care, of course, not to allow the athlete to engage in activity which might endanger the well-being of the person being trained.

The methods of the present invention, in addition to training for sports associated purposes such as competitive sports and mountaineering, may also be used by individuals in the military and in aerospace industries. The device (typically with a normal or elevated Fio₂, HeO₂ gas mixture) may also be used in the medical field as part of an exercise rehabilitation program. These programs are typically performed in patients suffering from cardiovascular, pulmonary diseases (cardiac rehabilitation, or pulmonary rehabilitation respectively) or as part of a weight reduction or metabolic management program.

It will be appreciated by those skilled in the art that changes could be made to the embodiments described above without departing from the broad inventive concept thereof. It is understood, therefore, that this invention is not limited to the particular embodiments disclosed, but it is intended to cover modifications that are within the spirit and scope of the invention, as defined by the appended claims.

We claim:

1. A method of training an individual to improve performance in exercise, sports or other competitive activity by achieving a higher level of training for muscle groups associated with said competitive activity, comprising having said individual breath a low-density gas mixture comprising helium and oxygen (HeO₂), said breathing of said low-density gas mixture being done while said individual is training, said training being performed to a point of exertion reasonably approaching the limits of performance for said individual; whereby the viscous resistance associated with breathing said low-density gas mixture is low as compared with the viscous resistance associated with breathing air, the amount of oxygen consumed by the muscles involved with breathing is low as compared with consumption of oxygen of said muscles involved with breathing when said individual is breathing air, and the oxygen available for exercising the muscles being trained is increased to provide increased devel-
development of the muscles being trained as compared with the development associated with breathing air while training.

2. A method of training as in claim 1, wherein said gas mixture is delivered by a viscous circuit under a positive airway pressure.

3. A method of training as in claim 1, wherein said individual wears an interface which delivers the low density gas mixture to the individual.

4. A method of training as in claim 3, wherein said interface is connected via a tubing circuit to a low resistance positive airway pressure (PAP) assist ventilator device which is connected to flexible tubing connected through a pressure regulator to a liquid gas source that supplies the low-density gas mixture to the PAP device, wherein said interface and said tubing circuit comprises a breathing circuit.

5. A method of training as in claim 4, further comprising a gas impermeable (or very low permeability) bag, vessel, or other type of container, connected to the liquid gas source and to the PAP device via flexible tubing, wherein the gas impermeable container serves as a reservoir to receive, store, and condition gas or gasses that are delivered to the PAP device from the liquid gas source.

6. A method of training as in claim 5, wherein the gas impermeable bag/vessel contains a pressure sensor which communicates with the pressure regulator on the liquid gas source and/or with the PAP device to either directly or through an external electronics computer system in order to regulate gas flow into the gas impermeable bag.

7. A method of training as in claim 5, wherein the volume of the gas impermeable bag ranges from about 5 liters to about 170 liters or more.

8. A method of training as in claim 1, wherein the individual is a healthy individual or an individual suffering from an illness for which exercise may be a beneficial treatment.

9. The method according to claim 1, wherein the HeO₂ gas mixture provides a fractional inspired oxygen in the range of 12% to 60% or greater, and a corresponding fractional inspired helium in the range of 40 or lower and 88%.

10. The method according to claim 3, wherein the interface comprises a mask selected from the group consisting of a full-face mask/face shield, a nasal style mask, an oro-nasal style mask, a mouth-only style mask, a high flow nasal cannula and any other style mask capable of delivering gas and pressure from the breathing circuit to the individual, wherein said mask has a fixed or a variable leak function, wherein said mask optionally vents exhaled breath into the atmosphere through a resistance, and wherein said mask optionally contains an adapter capable of accepting power and/or transmitting data between the mask and the PAP device.

11. The method according to claim 1, wherein the tubing circuit consists of a flexible, reinforced tube having adapters configured to fit into the PAP device and the interface, and wherein the tubing circuit is gas impermeable and optionally contains internal wires for transmitting electrical power and/or data between the PAP device and the interface.

12. The method according to claim 1, wherein the individual breaths the low-density gas mixture during exercise training to reduce the work of breathing by the individual, and immediately after exercise training to reduce recovery time from the exercise training.

13. The method according to claim 12, wherein the low-density gas mixture is delivered into the breathing circuit in a closed configuration in which the low-density gas mixture is supplied directly to the PAP device via the flexible tubing connected to a liquid gas source, or is delivered into the breathing circuit in an open configuration in which the PAP device draws air from the surrounding environment at ambient atmospheric pressure into the breathing circuit and the low-density gas mixture is delivered into the tubing circuit or into the interface or into both the tubing circuit and the interface, said HeO₂ gas mixture being delivered via flexible tubing connected to a liquid gas source.

14. The method according to claim 1, wherein the liquid gas source is an external high capacity liquid gas storage tank or a liquid gas canister, or a traditional gas canister.

15. The method according to claim 1, wherein the interface or the tubing circuit contains an end tidal carbon dioxide sensor safety override system capable of measuring carbon dioxide levels in the breathing circuit, wherein detection of unsafe levels of carbon dioxide levels alters the PAP device by altering system flow or leak levels to allow for greater carbon dioxide escape from the breathing circuit, by changing pressure or flow levels, or by terminating function of the PAP device.

16. The method according to claim 1, wherein the PAP device contains internal flow sensors and pressure sensors capable of sensing variable inspiratory rates, expiratory rates and leak rates within the breathing circuit, and wherein the PAP device has an internal electronic algorithm which varies the pressure delivered within the breathing circuit in order to maintain a desired pressure.

17. The method according to claim 16, wherein the PAP device generates a continuous level fixed respiratory pressure ranging from about 4 cm to about 30 cm of H₂O pressure.

18. The method according to claim 16, wherein the PAP device generates a bi-level respiratory pressure in which the PAP device cycles between a higher inspiratory pressure and a lower expiratory pressure, said inspiratory pressure and said expiratory pressure ranging from about 4 cm to about 30 cm of H₂O pressure.

19. The method according to claim 1, wherein the PAP device is powered by a power source selected from the group consisting of an internal or external power supply for with in an alternating current wall plug and an internal or external battery pack power supply.

20. A method of simulating high altitude exercise training in an individual comprising breathing a low-density gas comprised of a mixture of helium gas and a hypoxic level of oxygen gas (He-hypO₂) by having an individual wear an interface which delivers the He-hypO₂ gas mixture to the individual, said interface connected via a tubing circuit to a low resistance positive airway pressure (PAP) assist ventilator device which is connected via flexible tubing to a liquid gas source that supplies the He-hypO₂ gas mixture to the PAP device, wherein said interface and said tubing circuit comprises a breathing circuit.

21. The method according to claim 20, wherein the He-hypO₂ gas mixture provides an FiO₂ ranging from about 12% to about 20% and a corresponding FiHe ranging from about 88% to about 80%.

22. The method according to claim 20, wherein the PAP device contains an oxygen sensor system capable of measuring the concentration of oxygen in the breathing circuit and communicating this information to a control system of the PAP device.

23. The method according to claim 20, wherein the He-hypO₂ is delivered into the breathing circuit in a closed configuration in which the He-hypO₂ gas mixture is supplied
directly to the PAP device via the flexible tubing connected to an external (high capacity liquid) gas storage tank.

24. The method according to claim 20, wherein the He-hypO₂ is delivered into the breathing circuit in an open configuration in which the PAP device draws air from the surrounding environment at ambient atmospheric pressure into the breathing circuit and helium gas is delivered into the breathing circuit to dilute the FIO₂, wherein the helium gas is delivered into the tubing circuit or into the interface or into both the tubing circuit and the interface, wherein the helium gas is delivered via flexible tubing connected to a liquid helium gas supply, wherein helium flow rate is controlled by an electronic pressure regulator connected to the liquid helium gas supply, said pressure regulator controlled by an electronics system of the PAP device, wherein the helium flow rate is varied according to the individual’s minute ventilation rate and may also be controlled by the oxygen sensor system, pressure sensor, flow sensor or safety sensors.

25. The method according to claim 20, wherein the PAP device contains a pulse oxymetry safety override system consisting of a pulse oxymeter probe which is worn by the individual during exercise training, said pulse oxymeter probe capable of transmitting data either wired or wirelessly from the oxymeter to the PAP device electronics system, wherein a safety protocol will interrupt helium delivery or alter PAP device function if unsafe oxygen levels are detected in the individual.

26. A method of training an individual to improve performance in exercise, sports or other competitive activity by achieving a higher level of training for muscle groups associated with said competitive activity, comprising having said individual breath a low-density gas mixture comprising a mixture of helium and a hypoxic level of oxygen gas (He-hypO₂), said breathing of said low-density gas mixture being done while said individual is training, said training being performed to a point of exertion reasonably approaching the limits of performance for said individual; whereby the viscous resistance associated with breathing said low-density gas mixture is low as compared with the viscous resistance associated with breathing air, the amount of oxygen consumed by the muscles involved with breathing is low as compared with consumption of oxygen of said muscles involved with breathing when said individual is breathing air, and the oxygen available for exercising the muscles being trained is increased to provide increased development of the muscles being trained as compared with the development associated with breathing air while training.

27. A method of training as in claim 26, wherein said gas mixture is delivered by a viscous circuit under a positive airway pressure.

28. A method of training as in claim 1, wherein the method is used to train different muscle groups at different times.

29. A method as in claim 1 further comprising training with the lungs to an extreme level of performance by increasing the workload associated with breathing by providing high viscous resistance passages for inhalation by the individual undergoing training.

30. A method as in claim 29 wherein the low density gas mixture is a hypoxic mixture comprising helium and oxygen.

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