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(54) **SYSTEMS AND METHODS FOR
BREATHING EXERCISE REGIMENS TO
PROMOTE ISCHEMIC PRECONDITIONING**

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(58) **Field of Classification Search** 600/300,
600/301, 481, 529-538; 482/13; 128/200.24
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,518,985 A	7/1970	Quinton
3,675,640 A	7/1972	Gatts
3,802,698 A	4/1974	Burian et al.
3,978,849 A	9/1976	Geneen
4,278,095 A	7/1981	Lapeyre
4,281,663 A	8/1981	Pringle
4,301,808 A	11/1981	Taus
4,358,105 A	11/1982	Sweeney, Jr.
4,367,752 A	1/1983	Jimenez et al.

4,425,921 A 1/1984 Fujisaki et al.

4,436,097 A 3/1984 Cunningham

4,566,456 A 1/1986 Koning et al.

4,613,129 A 9/1986 Schroeder et al.

4,622,980 A 11/1986 Kunig

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2091101 9/1993

(Continued)

OTHER PUBLICATIONS

Acker J.E., Jr. et al., "Assessing psychological problems from a
cardiologist's point of view," (Abstract) *Advances in Cardiology*, 31
at 218-22 (1982).

(Continued)

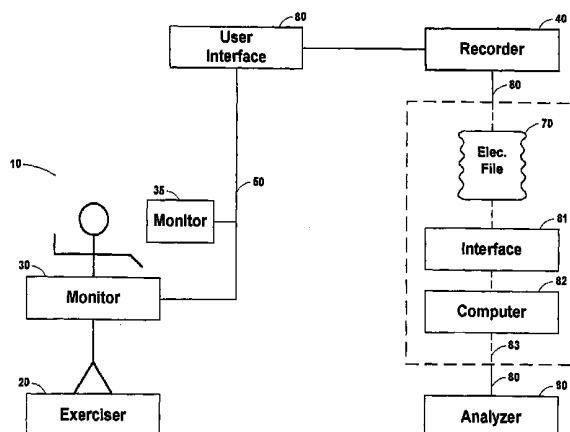
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(57) **ABSTRACT**

Systems and methods for promoting ischemic preconditioning in individuals are provided. Ischemic preconditioning is provided by exercise treatments. The exercise treatments consist of breathing exercise regimens with breathing sequences of oxygenating and non-oxygenating phases coordinated with stress-relaxation cycles. The breathing sequences are designed to induce periods of ischemia. The individualized exercise treatments can induce optimal number of periods of ischemia separated by suitable intervals to provide effective ischemic preconditioning.

16 Claims, 7 Drawing Sheets



U.S. PATENT DOCUMENTS

4,683,891	A	8/1987	Cornellier et al.	
4,719,920	A	1/1988	Alt et al.	
4,788,983	A	12/1988	Brink et al.	
4,807,639	A	2/1989	Shimizu et al.	
4,867,442	A	9/1989	Matthews	
4,883,063	A	11/1989	Bernard et al.	
4,896,675	A	1/1990	Ohsuga et al.	
4,938,228	A	7/1990	Righter et al.	
4,981,295	A	1/1991	Belman et al.	
5,007,430	A	4/1991	Dardik	
5,163,439	A	11/1992	Dardik	
5,267,568	A	12/1993	Takara	
5,410,472	A	4/1995	Anderson	
5,752,521	A	5/1998	Dardik	
5,810,737	A	9/1998	Dardik	
5,891,047	A *	4/1999	Lander et al.	600/516
5,921,891	A	7/1999	Browne	
6,212,135	B1 *	4/2001	Schreiber	368/107
6,662,032	B1	12/2003	Gavish et al.	

FOREIGN PATENT DOCUMENTS

CN	1095917	12/1994
DE	3045923	9/1981
DE	3409792	9/1984
DE	3532620	3/1986
DE	4338958	5/1994
EP	5949	12/1979
EP	117330	9/1984
EP	172747	2/1986
EP	181067	5/1986
EP	255621	2/1988
EP	419103	3/1991
EP	556702	8/1993
EP	922434	6/1999
EP	956819	11/1999
FI	8304152	5/1985
FI	8900776	8/1989
FI	9504300	3/1996
FR	2569158	2/1986
FR	2599616	12/1987
GB	2052051	1/1981
GB	2165352	4/1986
GB	2184361	6/1987
GB	2253706	9/1992
GB	2306659	5/1997
JP	07313474	12/1995
WO	85/00279	1/1985
WO	90/12538	11/1990
WO	93/14807	8/1993
WO	94/02904	2/1994
WO	97/22295	6/1997
WO	01/02049	1/2001

OTHER PUBLICATIONS

Ades P.A. et al., "Hypertension, exercise and beta-adrenergic blockade," (Abstract) *Annals of Internal Medicine*, 109 (8) at 629-34 (Oct. 15, 1988).

Aizaki T. et al., "Development of an ambulatory 24-hour recording device of electrocardiogram and exercise intensity and its analytic system," (Abstract) *Japan Journal of Med. Electron. Biol. Eng.* 32/2 at 83-90 (1994).

Al-Aweel J.C. et al., "Postictal heart rate oscillations in partial epilepsy," *Neurology*, 53 at 1590-1592 (1999).

Balogun J.A. et al., "Cardiovascular adjustments and perceived exertion during exercise on the BAPS board," (Abstract) *Disability and Rehabilitation*, 17 (8) at 430-6 (Nov.-Dec. 1995).

Belardinelli R. et al., "Exercise training improves left ventricular diastolic filling in patient with dilated cardiomyopathy. Clinical and prognostic implications," (Abstract) *Circulation*, 91 (11) at 2775-84 (Jun. 1, 1995).

Brusis O.A., "Rehabilitating coronary patients through exercise," (Abstract) *Postgraduate Medicine*, 44 (1) at p. 131-5 (Jul. 1968).

Bryniarski L. et al., "Effect of exercise rehabilitation on heart rate variability in hypertensives after myocardial infarction," (Abstract) *Journal of Hypertension*, 15 (12 pt 2) at 1739-43 (Dec. 1997).

Calzolari A.M. et al., "Rehabilitation of children after total correction of tetralogy of Fallot," (Abstract) *International Journal of Cardiology*, 28 (2) at 151-8 (Aug. 1990).

Cambach W. et al., "The effects of a community-based pulmonary rehabilitation programme on exercise tolerance and quality of life: a randomized controlled trial," (Abstract) *European Respiratory Journal*, 10 (1) at 104-13 (Jan. 1997).

Cerny F.J., "Relative effects of bronchial drainage and exercise for in-hospital care of patients with cystic fibrosis," (Abstract) *Phys. Ther.* 69/8 at 633-639 (1989).

Chen J. et al., "Ischemic tolerance in the brain," *Neurology*, vol. 48, p. 306 (Feb. 1997).

Claus J. et al., "Special aspects of physical training during the rehabilitation stage of coronary patients," (Abstract) *Herz*, 16 (4) at 199-209 (Aug. 1991).

Cohen M. V. et al., "Ischaemic preconditioning: can the protection be bottled?," *The Lancet*, vol. 342 (Jul. 1993).

Cooney M.M. et al., "Hydraulic resistance exercise benefits cardiovascular fitness of spinal cord injured," (Abstract) *Medicine and Science in Sports and Exercise*, 18 (5) at 522-5 (Oct. 1986).

Crakes J.G. et al., "Endpoints of chronobiologic cardiovascular monitoring during pregnancy for planning exercise and assessing effects," (Abstract) *Progress in Clinical and Biological Research*, 341A at 605-14 Ref: 28 (1990).

Czemin J. et al., "Effect of short-term cardiovascular conditioning and low-fat diet on myocardial blood flow and flow reserve," (Abstract) *Circulation*, 92 (2) at 197-204 (Jul. 15, 1995).

Dardik Irving I., "The Great Law of the Universe," *Cycles* at 265-277 (Mar.-Apr. 1994).

Dardik Irving I., "The Law of Waves and the Invalidation of the Scientific Method," *Cycles*, vol. 45, No. 2 at 49-60 (Feb. 1995).

Dardik Irving I., "The Origin of Disease and Health, Heart Waves: The Single Solution to Heart Rate Variability and Ischemic Preconditioning," *Cycles*, vol. 46, No. 3 at 67-77 (Dec. 1996).

Dardik Irving I., "The Origin of Disease and Health, Heart Waves: The Single Solution to Heart Rate Variability and Ischemic Preconditioning," *Frontier Perspectives*, vol. 6, No. 2 at 18-32 (Spring/Summer, 1997).

Dardik Irving I., "Research proposals for studying mind-body interactions, Cardiocybernetics: Relaxation through Exercise," *Advances, Journal of the Institute for the Advancement of Health*, vol. 8, No. 3 at 56-59 (Summer 1986).

De Vries H.A. et al., "Electromyographic comparison of single doses of exercise and meprobamate as to effects on muscular relaxation," (Abstract) *American Journal of Physical Medicine*, 51 (3) at 130-41 (Jun. 1972).

DiCarlo S. et al., "Hemodynamic and energy cost responses to changes in arm exercise technique," (Abstract) *Physical Therapy*, 63 (10) at 1585-92 (Oct. 1983).

Domenech R. J. et al., "Tachycardia preconditioning infarct size in dogs; Role of adenosine and protein Kinase C," (Oct. 1997).

Estok P.J. et al., "Jogging: cardiovascular benefits and risks," (Abstract) *Nurse Practitioner*, 11 (5) at 21-8 (May 1986).

Ewart C.K. et al., "Usefulness of self-efficacy in predicting overexertion during programmed exercise in coronary artery disease," (Abstract) *American Journal of Cardiology*, 57 (8) at 557-61 (Mar. 1, 1986).

Fletcher G.F., "Rehabilitative exercise for the cardiac patient. Early phase," (Abstract) *Cardiology Clinics*, 11 (2) at 267-75 Ref: 20 (May 1993).

Fletcher G.F. et al., "Continuous ambulatory electrocardiographic monitoring. Use in cardiac exercise programs," (Abstract) *Chest*, 71 (1) at 27-32 (Jan 1977).

Folgering H. et al., "Exercise limitations in patients with pulmonary diseases," (Abstract) *International Journal of Sports Medicine*, 15 (3) at 107-11 (Apr. 1994).

- Freedman R. et al., "Biofeedback and progressive relaxation treatment of sleep-onset insomnia: a controlled, all night investigation," (Abstract) *Biofeedback and Self Regulation*, 1 (3) at 253-71 Journal code: A15 (Sep. 1976).
- Fujita Y. et al., "Relationship between age-adjusted heart rate and anaerobic threshold in estimating exercise intensity in diabetics," (Abstract) *Diabetes Res. Clin. Pract.*, 8/1 at 69-74 (1990).
- Fulcher K.Y. et al., "Randomised controlled trial of graded exercise in patients with the chronic fatigue syndrome," (Abstract) *BMJ (Clinical Research Ed.)*, 314 (7095) at 1647-52 (Jun. 7, 1997).
- Garfinkel Alan et al., "Heart Rate Dynamics After Acute Cocaine Administration," *Journal of Cardiovascular Pharmacology*, vol. 19, No. 3 at 453-459 (1992).
- Gho B. C. G. et al., "Myocardial Protection by Brief Ischemia in Noncardiac Tissue," *Circulation* vol. 94, No. 9 (Nov. 1996).
- Goldberg A.P. et al., "Therapeutic benefits of exercise training for hemodialysis patients," (Abstract) *Kidney International Supplement*, 16 at S303-9 (Dec. 1983).
- Gordon N.F. et al., "Exercise and mild essential hypertension," (Abstract) *Primary Care; Clinics in Office Practice*, 18 (3) at 683-94 Ref: 60 (Sep. 1991).
- Greer M. et al., "Physiological responses to low-intensity cardiac rehabilitation exercises," (Abstract) *Physical Therapy*, 60 (9) at 1146-51 (Sep. 1980).
- Hertzeanu H.L. et al., "Ventricular arrhythmias in rehabilitated and nonrehabilitated post-myocardial infarction patients with left ventricular dysfunction," (Abstract) *American Journal of Cardiology*, 71 (1) at 24-7 (Jan. 1, 1993).
- Hooker S.P. et al., "Physiologic effects of electrical stimulation leg cycle exercise training in spinal cord injured persons," (Abstract) *Archives of Physical Medicine and Rehabilitation*, 73 (5) at 470-6 (May 1992).
- Hrushesky William J. M., "Timing is everything," *The Sciences*, 32-37 (Jul./Aug. 1994).
- Iwadare M. et al., "Exercise prescription for physical training in hypertensive patients," (Abstract) *Nippon Rinsho. Japanese Journal of Clinical Medicine*, 50 Suppl. at 160-7 (May 1992).
- Jovanovic-Peterson L. et al., "Randomized trial of diet versus diet plus cardiovascular conditioning on glucose levels in gestational diabetes," (Abstract) *American Journal of Obstetrics and Gynecology*, 161 (2) at 415-9 (Aug. 1989).
- Kamata H. et al., "Semi-supervised exercise using a step machine at home after myocardial infarction," (Abstract) *Journal of Cardiology*, 29 (1) at 23-8 (Jan. 1997).
- Kato J. et al., "Cardiorespiratory effects of weight reduction by exercise in middle-aged women with obesity," (Abstract) *Journal of International Medical Research*, 22 (3) at 160-4 (May-Jun. 1994).
- Kellermann J.J., "Rationale of exercise therapy in patients with angina pectoris with normal and impaired ventricular function," (Abstract) *Chest*, 101/5 Suppl. at 322S-325S (1992).
- King C.N. et al., "Exercise testing and prescription. Practical recommendations for sedentary," (Abstract) *Sports Medicine*, 21 (5) at 326-36 (May 1996).
- Koch S.M., "Effect of passive range of motion on intracranial pressure in neurosurgical patients," (Abstract) *Journal of Critical Care*, 11 (4) at 176-9 (Dec. 1996).
- Kohn M. et al., "Effects of exercise therapy on blood pressure and hormonal factors in subjects with borderline and mild hypertension," (Abstract) *Bull. Phys. Fitness Res. Inst.* -72 at 81-86 (1989).
- Leitch J.W. et al., "Randomized trial of a hospital-based exercise training program after acute myocardial infarction: cardiac autonomic effects," (Abstract) *Journal of the American College of Cardiology*, 29 (6) at 1263-8 (May 1997).
- Malik Marek et al., "Heart Rate Variability: Standards of Measurement, Physiological Interpretation, and Clinical Use," *A.N.E.*, vol. 1, No. 2, Pt. 1, at 151-181 (Apr. 1996).
- Malikov V.A. et al., "Selection of optimal training exercise and training schedule for patients with ischemic heart disease at the early periods after aortocoronary bypass," (Abstract) *Kardiologia* 31 (7) at 17-20 (Jul. 1991).
- Malpas et al., "Circadian Variation Of Heart Rate Variability," *Cardiovascular Research*, vol. 24, at 210-213 (1990).
- Marcelino J. et al., "Assessment of a circuit of exercises through heart rate response," (Abstract) *International Journal of Cardiology*, 49 (2) at 153-8 (Apr. 1995).
- Masuoka, Toshiharu, "A Clinical Study of Exercise Training after Reperfusion Therapy in Patients with Myocardial Infarction," (Abstract) *Abstracts For Hiroshima Daigaku Igaku Zasshi*, 43(3) at 149-160 (1995).
- Maynard T., "Exercise: Part II. Translating the exercise prescription," (Abstract) *Diabetes Educator* 17 (5) at 384-95 Ref: 13 (Sep.-Oct. 1991).
- Mead W.F., "Exercise rehabilitation after myocardial infarction," (Abstract) *American Family Physician*, 15 (3) at 121-5 (Mar. 1977).
- Melton-Rogers S et al., "Cardiorespiratory responses of patients with rheumatoid arthritis during bicycle riding and running in water," (Abstract) *Physical Therapy*, 76 (10) at 1058-65 (Oct. 1996).
- Mertens D.J. et al., "Exercise training for patients with chronic atrial fibrillation," (Abstract) *Journal of Cardiopulmonary Rehabilitation*, 16 (3) at 193-6 (May-Jun. 1996).
- Meyer K. et al., "Resistance exercise in comparison to bicycle ergometry. A study into the suitability of resistance training in exercise therapy for coronary patients," (Abstract) *Z. Kardiol.*, 81/10 at 531-537 (1992).
- Meyer K. et al., "Can the training of coronary patients be monitored by readily measurable parameters?," (Abstract) *Herz*, 16 (4) at 251-6 (Aug. 1991).
- Mineo K. et al., "Graded exercise in three cases of heart rupture after acute myocardial infarction," (Abstract) *American Journal of Physical Medicine and Rehabilitation*, 74 (6) at 453-7 (Nov. -Dec. 1995).
- Mink B.D., "Pulmonary concerns and the exercise prescription," (Abstract) *Clinics in Sports Medicine*, 10 (1) at 105-16 Ref: 33 (Jan. 1991).
- Moore R. Y., "A clock for the ages," *Science*, vol. 284 (Jun. 1999).
- Neubauer B. et al., "Analysis of heart rate variations in patients with multiple sclerosis," *Journal of Neurology, Neurosurgery, and Psychiatry*, 41 at 417-419 (1978).
- Oldridge N.B., "Carotid palpation, coronary heart disease and exercise rehabilitation," (Abstract) *Medicine and Science in Sports and Exercise*, 13 (1) at 6-8 (1981).
- Otsuka Kuniaki et al., "Circadian rhythmic fractal scaling of heart rate variability in health and coronary artery disease," *Clinical Cardiology*, 20 at 631-638 (1977).
- Pennisi, Elizabeth, "In Nature, Animals that Stop and Start Win the Race," *Science*, 288 at 83-85 (Apr. 7, 2000).
- Petzinger, Jr. T., "Two doctors give new meaning to taking your business to heart," *The Wall Street Journal*, p. B1 (1999).
- Przyklenk K. et al., "Regional Ischemic 'preconditioning' protects remote virgin myocardium from subsequent sustained coronary occlusion," *Circulation* vol. 87, No. 3 (Mar. 1993).
- Ramazanoglu Y.M. et al., "Cardiorespiratory response to physical conditioning in children with bronchial asthma," (Abstract) *Pediatric Pulmonology*, 1 (5) at 272-7 (Sep.-Oct. 1985).
- Redlin Uwe et al., "Exercise and human circadian rhythms: What we know and what we need to know," *Chronobiology International*, 14(2) at 221-119 (1997).
- Reilly K. et al., "Differences between a supervised and independent strength and conditioning program with chronic low back syndromes," (Abstract) *Journal of Occupational Medicine*, 31 (6) at 547-50 (Jun. 1989).
- Rousch Wade, "Can resetting hormonal rhythms treat illness?," *Science*, 269 at p. 1220-21 (1995).
- Samitz G., "Aerobic upper body exercise. An unused potential in exercise therapy," (Abstract) *Wien. Med. Wochenschr.*, 142/14 at 309-313 (1992).
- Schechtman V.L., "Dynamic Analysis of Cardiac R-R Intervals in Normal Infants Who Subsequently Succumbed to the Sudden Infant Death Syndrome," *Pediatric Research*, vol. 32, No. 6 at 606-612 (1992).
- Schwartz Tony, "Making Waves. Can Dr. Irv Dardik's Radical Exercise Therapy Really Work Miracles," *New York* at 31-39 (Mar. 18, 1991).

- Sparks K.E. et al., "Alternatives for cardiac rehabilitation patients unable to return to a hospital-based program," (Abstract) *Heart and Lung*, 22 (4) at 298-303 (Jul.-Aug. 1993).
- Stephens R. et al., "Effects of self-monitored exercise on selected blood chemistry parameters of end-stage renal disease patients," (Abstract) *American Journal of Physical Medicine and Rehabilitation*, 70 (3) at 149-53 (Jun. 1991).
- Stevens R. et al., "Comparison of supervised and unsupervised exercise training after coronary bypass surgery," (Abstract) *American Journal of Cardiology*, 53 (11) at 1524-8 (Jun. 1, 1984).
- Tamiya N., "Study of physical fitness in children, and its application to pediatric clinics and sports medicine," (Abstract) *Hokkaido Igaku Zasshi. Hokkaido Journal of Medical Science*, 66 (6) at 849-67 (Nov. 1991).
- Taniguchi K. et al., "PredischARGE early exercise therapy in patients with acute myocardial infarction on the basis of anaerobic threshold (AT)," (Abstract) *Jpn. Circ. J.*, 54/11 at 1419-1425 (1990).
- Todd I.C. et al., "Effect of exercise training on the total ischaemic burden: an assessment by 24 hour ambulatory electrocardiographic monitoring," (Abstract) *British Heart Journal*, 68 (6) at 560-6 (Dec. 1992).
- Tsuji Hisako et al., "Reduced Heart Rate Variability and Mortality Risk in an Elderly Cohort, The Framingham Heart Study," *Circulation*, vol. 90, No. 2 at 878-883 (Aug. 1994).
- Ueshima K. et al., "Management and evaluation of non-supervised home exercise program in a convalescent phase of acute myocardial infarction," (Abstract) *Japanese Circulation Journal*, 54 (11) at 1437-42 (Nov. 1990).
- van Dixhoorn J. et al., "Physical training and relaxation therapy in cardiac rehabilitation assessed through a composite criterion for training outcome," (Abstract) *American Heart Journal*, 118 (3) at 545-52 (Sep. 1989).
- Waddington J.L. et al., "Resting heartrate variability in man declines with age," *Experience*, 35 at 1197-1198 (1979).
- Wheeler Timothy et al., "Cardiac Denervation in Diabetes," *British Medical Journal*, at p. 584-586 (Dec. 8, 1973).
- Williams L.R. et al., "Vascular rehabilitation: benefits of a structured exercise/risk modification program," (Abstract) *Journal of Vascular Surgery*, 14 (3) at 320-6 (Sep. 1991).
- Williams M.A. et al., "Guidelines for exercise therapy of the elderly after myocardial infarction," (Abstract) *Eur. Heart J. 5, Supplement E* at 121-123 (1984).
- Williams, Terrie M. et al., "Sink or Swim: Strategies for Cost-Efficient Diving by Marine Mammals," *Science* 288 at 133-136 (Apr. 7, 2000).
- Wolfe L.A. et al., "Prescription of aerobic exercise during pregnancy," (Abstract) *Sports Medicine*, 8 (5) at 273-301 Ref: 133 (Nov. 1989).
- Wright N.C. et al., "Aerobic walking in slowly progressive neuromuscular disease: effect of a 12-week program," (Abstract) *Archives of Physical Medicine and Rehabilitation*, 77 (1) at 64-9 (Jan. 1996).
- Yellon, Derek M. et al., "A 'Second Window of Protection' or Delayed Preconditioning Phenomenon: Future Horizons for Myocardial Protection?," *J. Mo. Cell Cardiol.* 27 at 1023-1034 (1995).
- Yellon, Derek M. et al., "Ischaemic preconditioning: present position and future directions," *Cardiovascular Research*, 37 at 21-33 (1998).

* cited by examiner

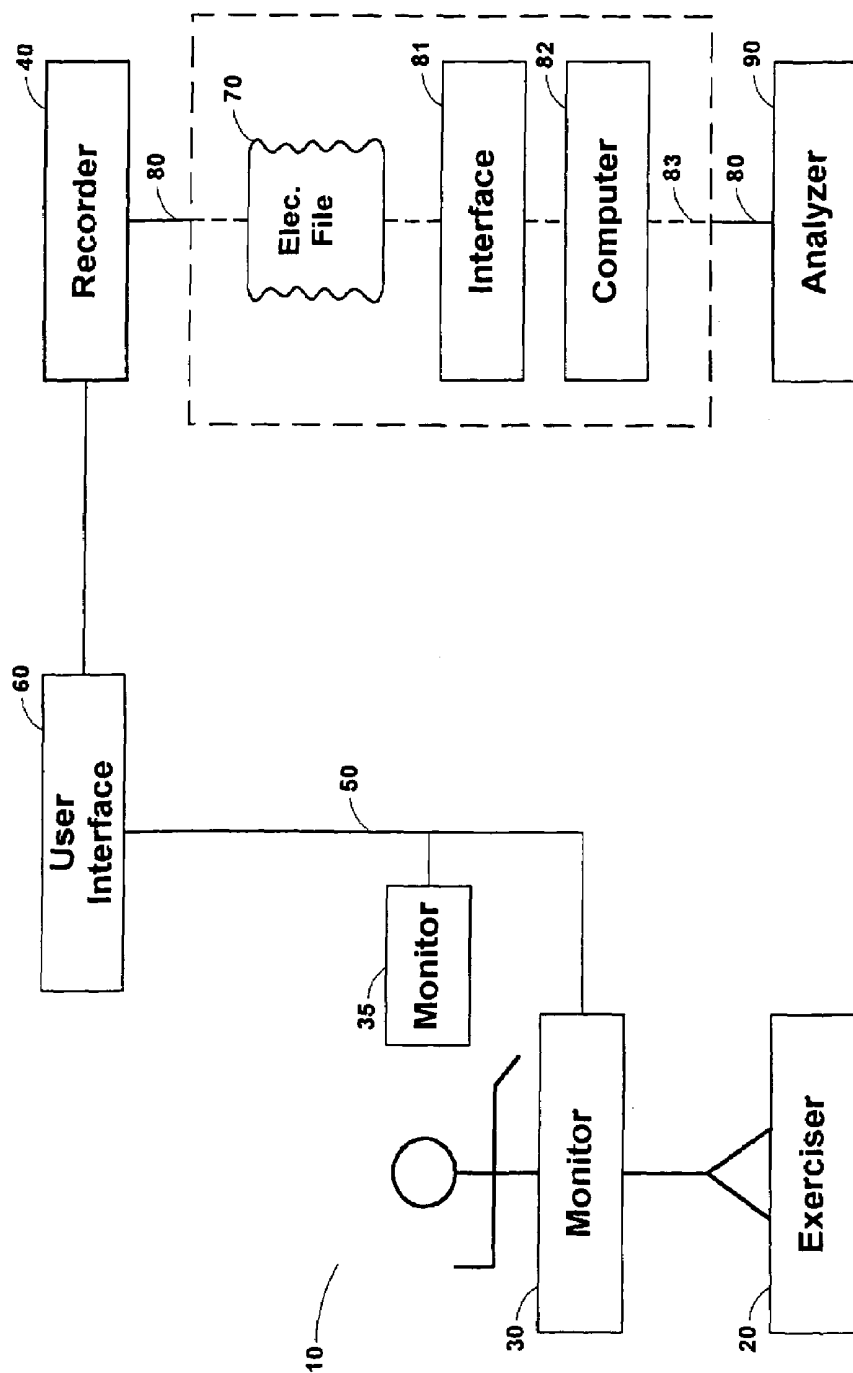
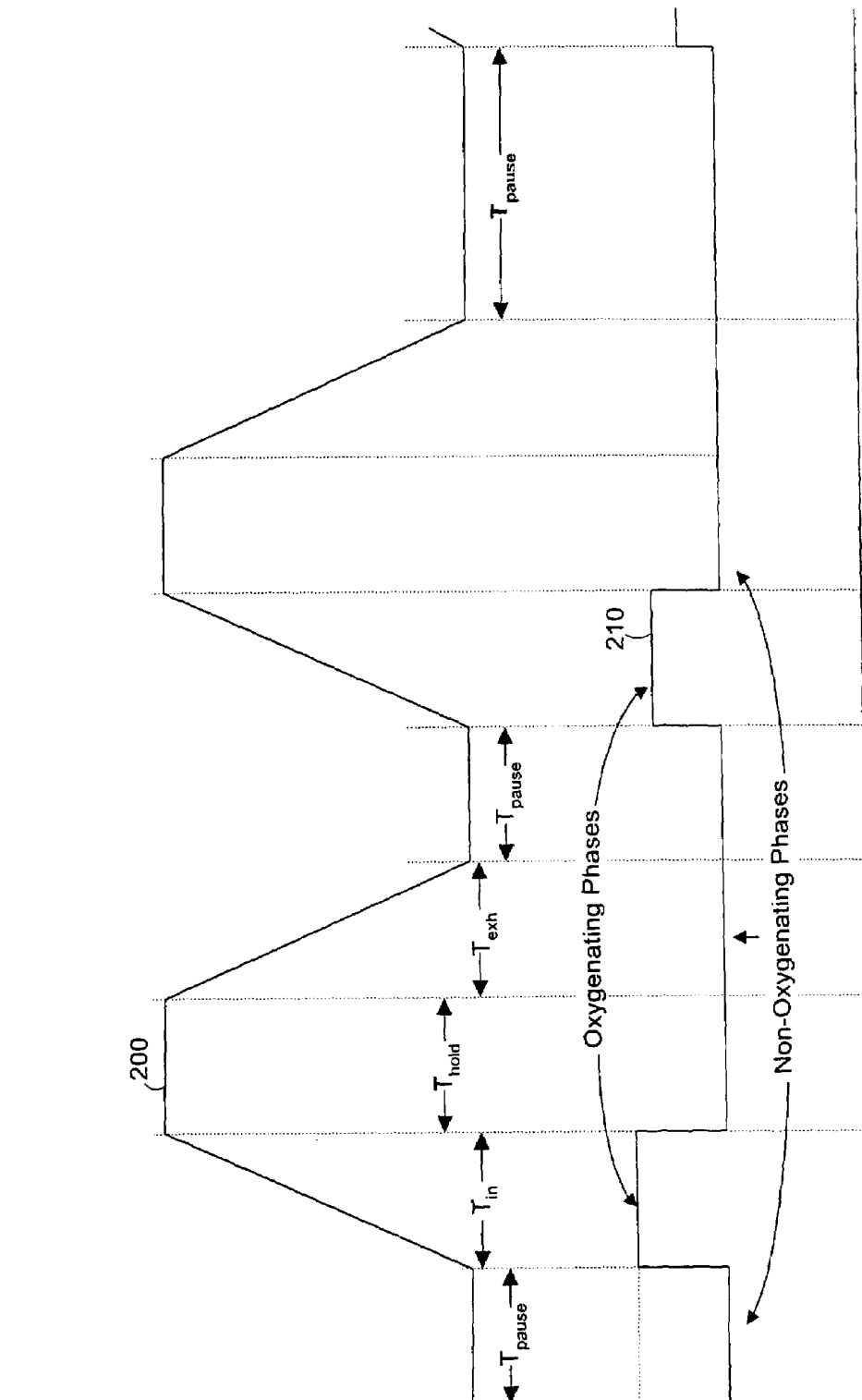


FIG. 1



Time \uparrow

FIG. 2

FIG. 3

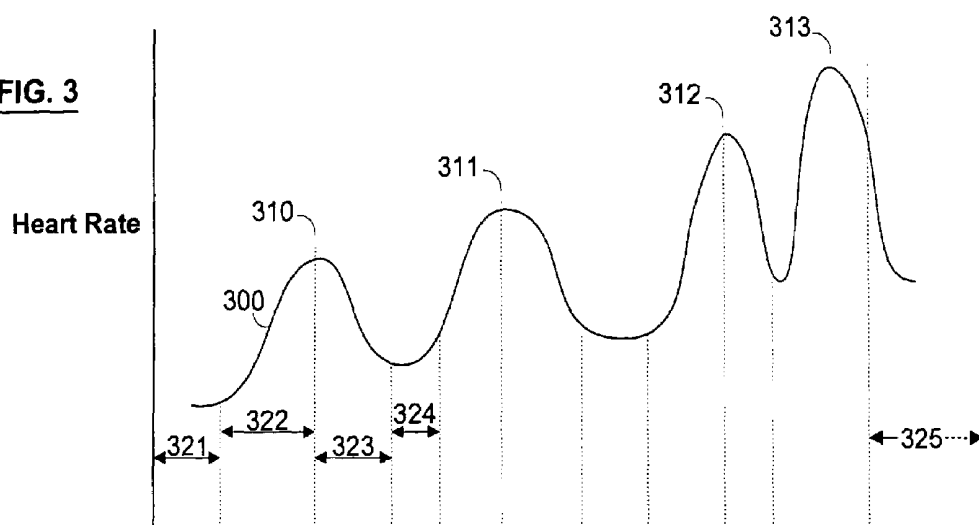


FIG. 4

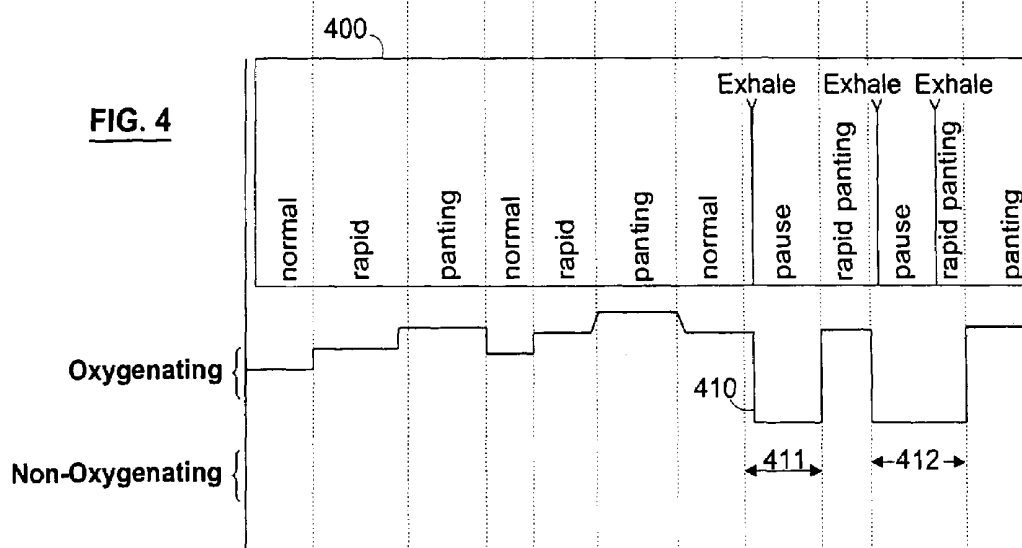
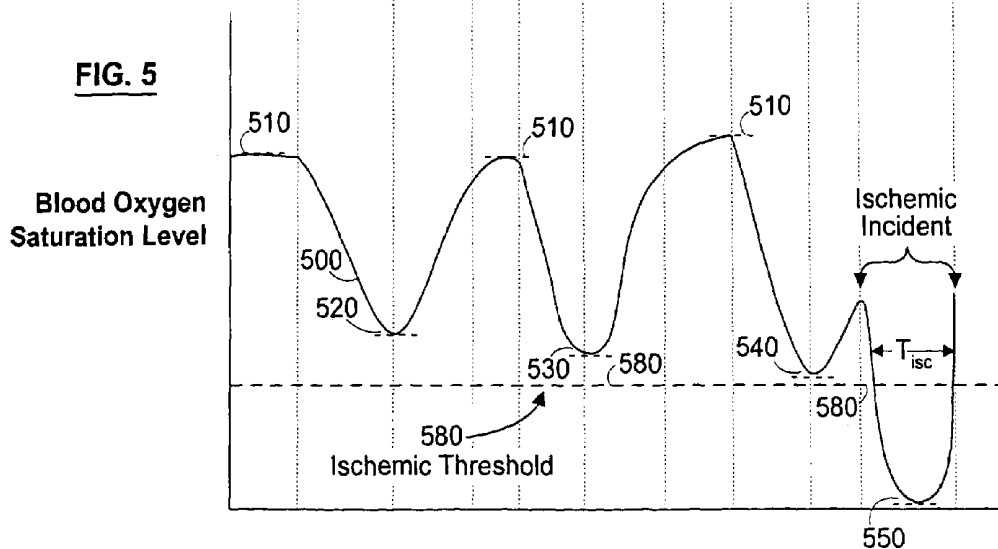


FIG. 5



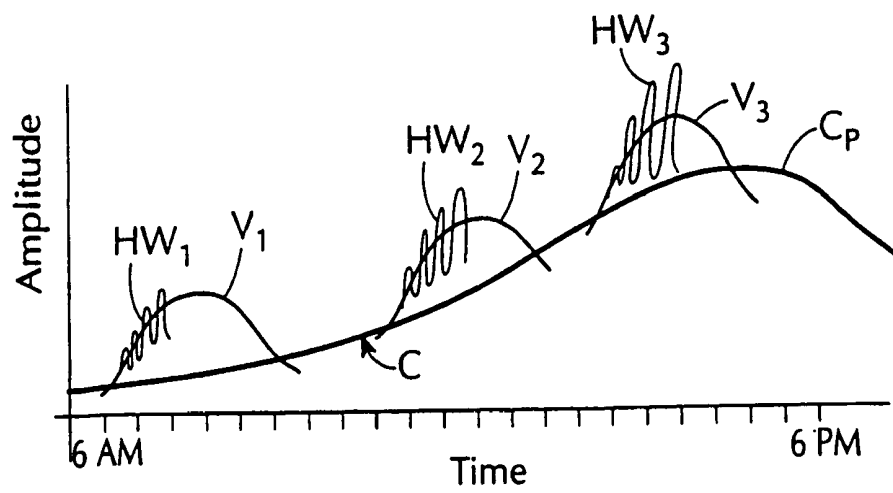
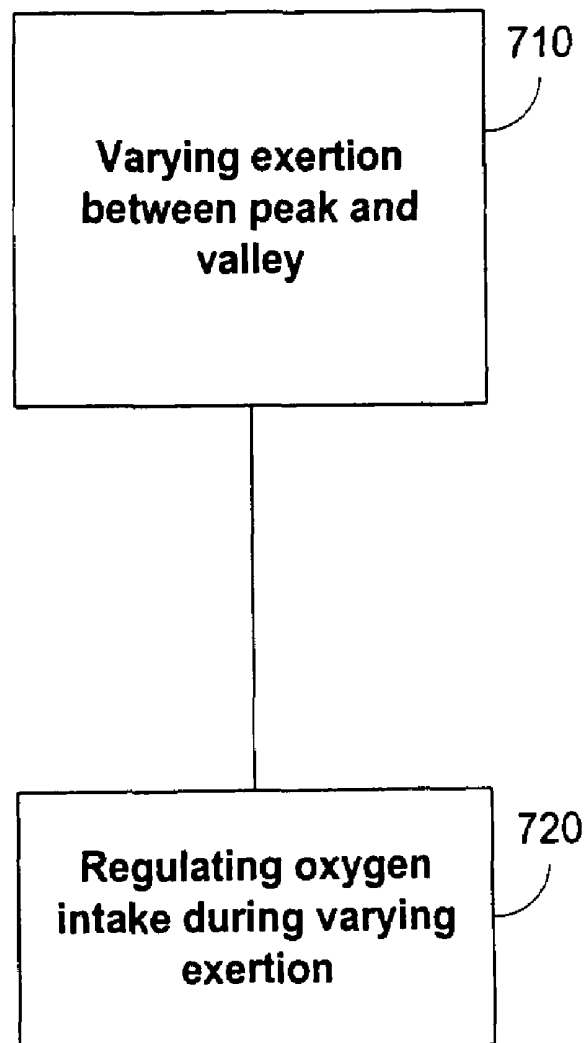


FIG. 6

**FIG. 7**

800

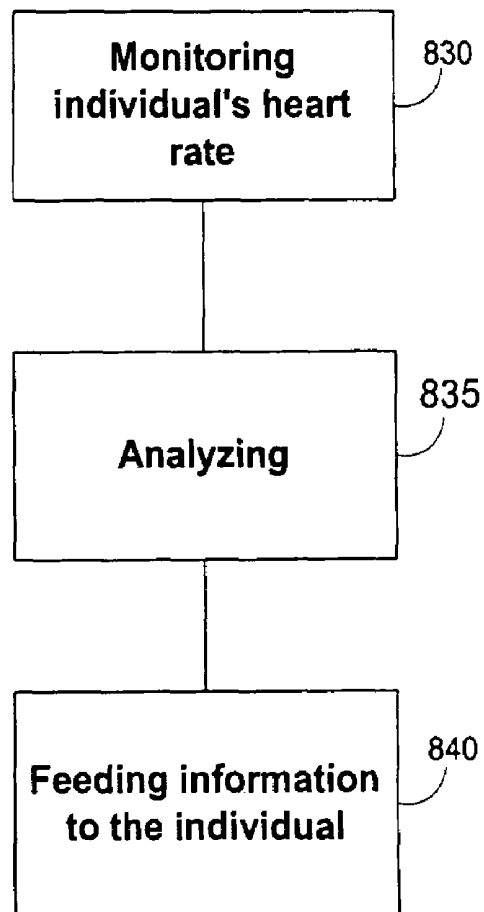


FIG. 8

900

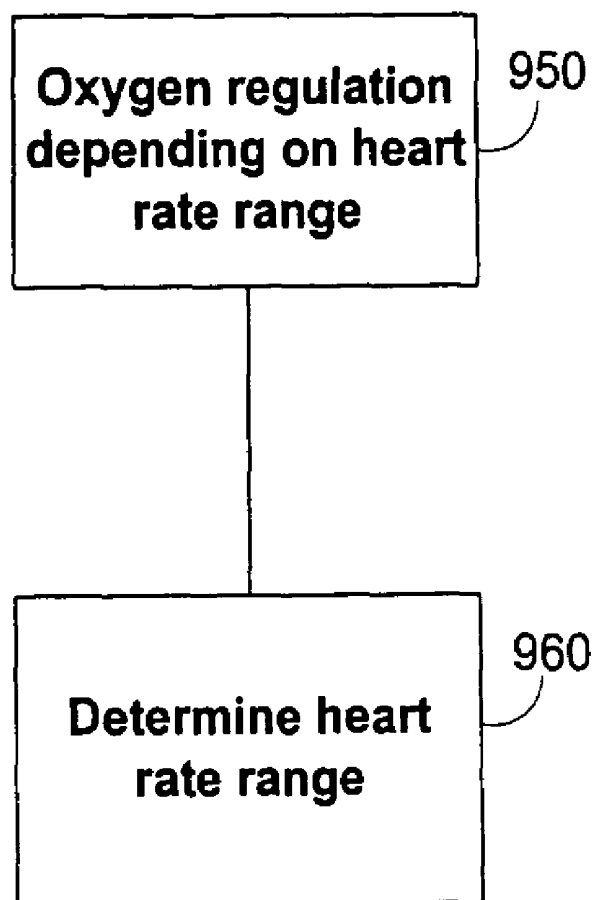


FIG. 9

SYSTEMS AND METHODS FOR BREATHING EXERCISE REGIMENS TO PROMOTE ISCHEMIC PRECONDITIONING

This is a divisional of application Ser. No. 09/841,218, U.S. Pat. No. 6,702,702 filed Apr. 24, 2001. This prior application is hereby incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention relates to systems and methods for promoting ischemic preconditioning in individuals. More particularly, the present invention relates to systems and methods for promoting ischemic preconditioning in individuals by exercise treatments that coordinate a breathing regimen with cycles of alternating stress and relaxation.

BACKGROUND OF THE INVENTION

Ischemic preconditioning is one of the most remarkable phenomena known to medical science. Brief periods of ischemia—a local shortage of oxygen-carrying blood supply, in biological tissue, renders that tissue more resistant to subsequent ischemic insults.

Ischemic preconditioning has been observed in myocardial tissue of dogs who were pretreated by alternately clamping and unclamping coronary arteries to intermittently turn off the blood flow to the heart. Dogs who were treated with an optimal number of four cycles of five-minute coronary occlusion followed by five-minute reperfusion, exhibited 75% smaller infarct sizes resulting from a subsequent forty-minute coronary occlusion. Fewer than four cycles of coronary occlusion resulted in insufficient preconditioning, more than four cycles did not provide further benefit.

Myocardial tolerance also develops in response to treatment that does not include coronary occlusion (i.e., ischemia) but increases demand for oxygenated blood. In dogs, a treatment comprising of five five-minute periods of tachycardia alternating with five minutes of recovery has been shown to reduce infarct sizes.

The myocardial resistance to infarct resulting from brief periods of ischemia has also been described in other animal species including rabbit, rat and pig. Ischemic preconditioning has also been demonstrated in humans. A second coronary occlusion during the course of coronary angioplasty often results in less myocardial damage than the first. Naturally occurring ischemic preconditioning of the myocardium has been found in humans suffering from bouts of angina.

Ischemic preconditioning occurs not only in myocardial tissue but also occurs in non-cardiac tissue including kidney, brain, skeletal-muscle, lung, liver and skeletal tissue. Further myocardial resistance to infarct exists even in virgin myocardium tissue following brief ischemia in spatially remote cardiac or non-cardiac tissue. Ischemic preconditioning also exhibits a temporal reach: An early phase develops immediately within minutes of the preconditioning ischemic injury and lasts for a few hours, and a late phase develops with circadian regularity twenty four hours later and reappears cyclically over several days, and then dissipates.

The spatial and temporal characteristics of ischemic preconditioning may be a manifestation of complex interactions between various underlying phenomena that are internal as well as external to the human body. However, the biochemical and cellular mechanisms underlying the phenomena of

ischemic preconditioning are not yet fully understood despite several research efforts. These research efforts have been motivated at least in part by the hope of developing pharmaceutical drugs which would provide the anti-infarct effect of ischemic preconditioning. Though ischemic preconditioning in a bottle may be desirable, it is as of now a chimera.

In contrast to a pharmacological approach to medicine, a general non-pharmacological approach to improving an individual's physiological condition is based on physical exercise. Dardik, U.S. Pat. Nos. 5,007,430, 5,800,737, 5,163,439, and 5,752,521, and Dardik, U.S. patent application Ser. No. 09/609,087, which are hereby incorporated by reference in their entireties, elaborate on non-pharmacological exercise treatments. The exercise treatments described in Dardik are based on a perspective view of human physiology that recognizes the wave nature of cardiac activity. For example, cardiac activity manifests itself through repetitive pulsations of the heart as a heart wave. The heart wave is a result of a superposition of many underlying waves (i.e., cycles) including behavioral waves (e.g., energy expenditure and recovery cycles in response to physical activity), environmental waves (e.g., day-night cycles), and internal waves (e.g., molecular biological, cellular, and chemical cycles). The exercise treatments described by Dardik may target specific heart wave properties to enhance an individual's overall physiological condition. For example, the treatments seek to beneficially increase heart rate variability.

However, neither of these exercise treatments nor any other in the prior art directly target ischemic preconditioning, for example, for improved myocardial behavior.

It is desirable to have systems and methods for promoting ischemic preconditioning in individuals. Recognition of cardiac activity as wave phenomenon that results from a superimposition of the effects of various endogenous and exogenous phenomena on human physiology is consistent with an empirical understanding of the spatial and temporal characteristics of ischemic preconditioning. This recognition may enable non-pharmacological treatments that provide individuals with protective powers of ischemic preconditioning for both prophylaxis and therapy.

SUMMARY AND OBJECTS OF THE INVENTION

It is an object of the present invention to provide systems and methods for providing ischemic preconditioning in individuals.

It is a further object of the present invention to provide non-pharmacological and non-invasive treatments with the goal of promoting ischemic preconditioning in individuals in order to enhance health, performance and longevity.

These and other objects of the invention are accomplished in accordance with the principles of the present invention by providing systems and methods for providing exercise treatments that can use individualized breathing exercise regimens for promoting ischemic preconditioning. The exercise regimens can include one or more exercise sessions. Each session can consist of breathing sequences co-ordinated with one or more stress-relaxation cycles. The breathing sequences can consist of one or more breathing cycles designed to induce at least one incidence of ischemia in the individual. The breathing cycles can be defined, for example, by defining time periods for inhalation, exhalation, holding breath, and not inhaling following exhalation. Each

of these cycles may be defined with respect to changes in the heart rate and predetermined exercise regimens including stress-relaxation cycles.

The stress-relaxation cycles of the exercise regimens, in accordance with the present invention, can be based, for example, on therapeutic and bio-rhythmic feedback principles taught by Dardik, U.S. Pat. Nos. 5,007,430, 5,800, 737, 5,163,439, and 5,752,521, and Dardik, U.S. patent application Ser. No. 09/609,087. The stress-relaxation cycles can consist of one or more cycles, during which the individual attempts to increase his or her heart rate, for example, to a target heart rate.

The periods of stress in the stress-relaxation cycles correspond to periods of high metabolic demand for oxygen in the individual's body tissues. The breathing sequences of the exercise regimens, in accordance with the present invention, can include one or more breathing cycles that control the time periods during which the individual's blood is oxygenated. By co-ordinating periods of oxygenation and non-oxygenation with periods of high metabolic demand, the breathing sequences can cause a sufficient degree of oxygen deprivation in the body tissues to cause ischemia. The timing and duration of non-oxygenating phases can be designed to control the intensity and duration of oxygen deprivation to produce ischemia in specific body tissue types such as myocardial, lung, skeletal-muscle, brain, and muscle tissues, etc., and any combination thereof.

One or more incidents of ischemia can be repeated at suitable intervals in one or more exercise sessions to provide optimal ischemic preconditioning.

The breathing exercise regimens can be synchronized with endogenous and exogenous cyclical phenomena in accordance with this invention by application of the principles for therapeutic treatment taught by Dardik, U.S. Pat. No. 5,800,737. For example, the breathing exercise treatments may be synchronized with circadian waves to provide ischemic preconditioning at periods later than the ischemic incidents themselves.

The breathing exercise regimens can also be designed to provide non-ischemic myocardial tolerance by increasing oxygen demand. Oxygen demand can be increased by sequences of rapid deep breathing cycles that substantially increase the individual's heart rate. Alternatively, oxygen can be increased or decreased by respectively increasing or decreasing the oxygen content of the subject's environment. Changes in the oxygen content may be performed in a preferably pre-determined cyclical fashion. A system for cycling the oxygen environment of an individual may, for example, be a hypo/hyper baric chamber. Such a chamber should preferably include the capacity to increase or decrease the oxygen content of the atmosphere within the chamber.

According to one embodiment of the present invention, an exercise treatment for promoting ischemic preconditioning can be conducted using an apparatus to monitor and analyze physiological parameters. The analysis of physiological parameters can be used to provide individualized breathing exercise regimens to promote ischemic preconditioning. The exercise treatment can include one or more exercise sessions. In the exercise sessions, the individual can be subject to one or more stress-relaxation cycles during which metabolic demand for oxygen in body tissues increases. A physiological parameter such as blood oxygen saturation level that is indicative of ischemia, i.e., oxygen deprivation, in body tissue may be monitored during a stress-relaxation cycle. A time trace of parameter data is recorded in an electronic file. Then, the time trace is analyzed, for example,

to assess parameter values relative to ischemic thresholds. The analysis can determine breathing cycle parameters and stress-relaxation cycle parameters that can cause ischemic incidents. These parameters can then be used to co-ordinate breathing sequences with one or more stress-relaxation cycles to generate individualized breathing exercise regimens that promote ischemic preconditioning.

According to another aspect of this invention, electronic networks, such as the Internet, can be used to receive data and provide information to the individual remotely.

BRIEF DESCRIPTION OF THE DRAWINGS AND THE APPENDIX

The above and other objects and advantages of the present invention will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

FIG. 1 is a schematic block diagram of an illustrative system constructed in accordance with the present invention;

FIG. 2 is an illustrative sequence of breathing cycles and a time trace of corresponding oxygenating and non-oxygenating phases in accordance with the present invention;

FIG. 3 is an illustrative time trace of heart rate data collected over several stress-relaxation cycles in an exercise session, in accordance with the present invention;

FIG. 4 shows an illustrative breathing regimen synchronized with the stress-relaxation cycles of the exercise session of FIG. 3, and a time trace of corresponding oxygenating and non-oxygenating phases, in accordance with the present invention;

FIG. 5 shows a time trace of blood oxygen saturation levels corresponding to the exercise session of FIG. 3 in accordance with the present invention;

FIG. 6 illustrates the relationship between heart waves generated during exercise sessions and exogenous phenomena such as circadian waves and ultradian waves, in accordance with present invention;

FIG. 7 is a flow chart of a preferred embodiment of a method in accordance with the present invention;

FIG. 8 is a flow chart showing further details of the method of FIG. 7, in accordance with the present invention; and

FIG. 9 is a flow chart of an alternative embodiment of a method in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In order that the invention herein described can be fully understood, the following detailed description is set forth.

FIG. 1 shows illustrative systems for exercise by an individual during performance of a breathing exercise regimen. One purpose of the systems is to incorporate ischemic preconditioning in the exercise.

Individual 10 is shown exercising on exerciser 20. Exerciser 20, for example, can be a treadmill machine, a trampoline, a stationary bicycle, or any other suitable exercising apparatus. Exerciser 20, however, is optional because exercise can be done without the aid of an exercise apparatus (e.g., running, jogging, jumping, walking, swimming, moving arms and shoulders, or swinging legs). Exercise may even be anaerobic activity. Monitor 35 monitors a physiological parameter indicative of the degree of ischemia. Physiological parameters which are indicative of ischemia are, for example, blood oxygen saturation levels, and in vivo

concentrations of biochemical compounds such as protein kinase C, nitric oxide, and antioxidant enzymes including superoxide dismutase, catalase, glutathione peroxidase, etc. Electronic monitor **30** may monitor other physiological parameters such as heart rate, heart rate variation, heart wave shape, blood pressure, and body temperature of individual **10**. Even though two monitors **30** and **35** are shown, it must be understood that any monitoring including the number of monitors used is optional. Monitors **30** and **35** are optional, because routine exercise sessions may be conducted without any monitoring in accordance with the present invention.

Monitors **30** and **35** can be any commercially available units that measure blood oxygen saturation levels and heart rates, respectively, and transmits data to recorder **40** through link **50**. Link **50** can be, for example, a magnetic coupling, a wireless transmission system, or any other electronic or electromagnetic network. Monitor **30** and **35** can be connected through link **50** to user interface **60**. Interface **60** can include passive output devices that provide to users visual, auditory, or tactile information regarding the blood oxygen saturation level, the heart rate or any other type of data. Interface **60** can also include an active output device such as a breathing machine, a respirator, a heart-lung machine, and any combination thereof. Recorder **40** can be, for example, a printer, a chart recorder, or other device (or combination of devices) that can record a time trace of data in an electronic file **70**.

Monitors **30**, recorder **40**, link **50**, and interface **60** can be obtained commercially as an integrated heart monitoring and recording unit (such as Lifewave Personal Coach™, by Lifewaves International Inc., of Califon, N.J.). Monitor **35** may also be connected to recorder **40**, through link **50** and interface **60** or otherwise. Link **80** connects recorder **40** to analyzer **90**, and can be local or remote to exerciser **20**. According to one embodiment, and as shown in FIG. 1, link **80** can include watch reading interface **81** (such as "Polar Advantage Interface System" Model 900622K sold under the trademark POLAR™, by Polar Electro Inc. of Woodbury, N.Y.), personal computer **82**, and Internet link **83**. It will be appreciated, however, that link **80** can be any electronic network that couples recorder **40** to analyzer **90** for data communication.

Analyzer **90** can include one or more electronic computing devices, preferably programmable computing devices (such as Model HP-VEE sold by Hewlett Packard Company, of Palo Alto, Calif.). It will be appreciated that analysis could, in some cases, exclusively or additionally involve manual computation or review, in accordance with the present invention. Analyzer **90** analyzes electronic file **70**, which contains physiological data (e.g., blood oxygen saturation level data) to calculate individualized breathing exercise regimens for promoting ischemic preconditioning.

The exercises can include one or more exercise sessions. Each session comprises breathing sequences coordinated with one or more one stress-relaxation cycles. The breathing sequences can consist of one or more breathing cycles designed to induce at least one incidence of ischemia in the individual. Exercise regimens generated by analyzer **90** can be provided to individual **10**, for example, over interface **60** or by any suitable means. Optionally, exercise regimens generated by analyzer **90** can be used to preprogram exerciser **20**.

FIG. 2 illustrates sequence of breathing cycles **200**. Each breathing cycle in sequence **200** consists of an inhalation phase of duration T_{in} that can be followed by an exhalation phase of duration T_{exh} . An optional holding phase of duration T_{hold} can separate the inhalation and exhalation phase.

Each breathing cycle may also include an optional pause phase of duration T_{pause} separating it from a subsequent breathing cycle. Only during the inhalation phase of duration T_{in} is blood oxygenated, as illustrated by trace **210**.

FIG. 3 shows illustrative time trace **300** of an individual's heart rate while exercising according to a breathing exercise treatment session which, for example, consists of four successive stress-relaxation cycles **310-313**. Some or all of cycles **310-313** can have designated target heart rates that an individual tries to attain during the cycle. Even though four cycles are shown for purposes of illustration, the number of stress-relaxation cycles in an exercise session can be as few as one at one end and at the other end can be limited only by what is physically possible, in accordance with the present invention. Breathing regimen **400** represented by "oxygenation and non-oxygenation" trace **410** in FIG. 4 is co-ordinated with stress-relaxation cycles **310-313**.

In each of exercise cycles **310-313**, the individual commences physical activity or exertion and continues the activity over first stress time period **322** in an attempt to raise the heart rate, for example, to a target heart rate. In each cycle **310-313**, after stress period **322**, the individual relaxes during relaxation time period **323** by gradually diminishing, or preferably, by abruptly ceasing physical activity. The exercise session can include pre-exercise rest period **321**, intervening rest periods **324** between successive exercise cycles **310-313**, and post-exercise resting period **325**. During the exercise session through each of cycles **310-313** for each of periods **321**, **322**, **323**, **324**, and **325** the individual is expected to breath according to breathing regimen **400**.

For cycles **310** and **311**, breathing regimen **400** can call on the individual to regulated his oxygen intake by breathing at a normal (resting) rate during periods **321**, a rapid rate during periods **322**, and at a panting rate through periods **323**. It will be appreciated that breathing regimen **400** can instruct the individual in general terms on the frequency and depth of breathing cycles for the normal, rapid, or the panting rates without specifically instructing the individual on breathing cycle parameters such as T_{in} , T_{exh} , T_{hold} , and T_{pause} , in accordance with the present invention.

Every single breathing cycle (as illustrated in FIG. 2) comprises an oxygenating phase and a non-oxygenating phase. However, in trace **310**, for ease of illustration, entire periods of normal, rapid or panting breathing that can consist of several single breathing cycles are shown as single oxygenating phases.

For later exercise cycles **312** and **313** which can correspond to higher target heart rates than the first two cycles, breathing regimen **400** calls upon the individual to exhale and then pause breathing during all of increasing stress periods **322** (cycles **312** and **313**) and also during all or portions of relaxation period **323** of cycles **313** (i.e., for cycle **312** $T_{exh} + T_{pause} \approx \text{period } 322$, and for cycle **313** $T_{exh} + T_{pause} \approx \text{period } 322 + \text{period } 323$). These extended pauses in breathing are represented by non-oxygenating phases **411** and **412** in trace **410**.

In FIG. 4 exhalation and pause durations T_{exh} and T_{pause} are shown for purposes of illustration as being comparable to periods **322** (and period **323**). However, the time duration ($T_{exh} + T_{pause}$) corresponding to non-oxygenating phases in a breathing cycle can be larger or smaller than stress period **322** and/or relaxation period **323**, in accordance with the present invention. For example, a breathing sequence may call on the individual to exhale and pause breathing only through a top portion of a stress period that corresponds to high stress, or may call on the individual to pause breathing throughout stress period **322**.

FIG. 5 shows illustrative time trace 500 of the individual's blood oxygen saturation level corresponding to heart rate time trace 300 and breathing regimen 400 as the individual is exercising and breathing according to breathing regimen 400. It will be understood that the blood oxygen levels shown in FIG. 5 are not clinically measured levels but are figurative levels used for purposes of illustration only.

First, considering exercise cycles 310 and 311, the individual's blood oxygen level is at resting level 510 during pre-exercise resting period 321, with blood oxygen levels maintained by normal (resting) breathing. Metabolic demand for oxygen in the individual's body tissues increases during periods of increasing stress (e.g., periods 322). In a normal physiological auto-response the individual may attempt to redress the imbalance between oxygen supply and demand by breathing more rapidly to replenish blood oxygen. However, at sufficiently increased stress, metabolic demand for oxygen in body tissues outpaces supply and blood oxygen saturation level drops to levels 520 and 530, for cycles 310 and 311, respectively. Nevertheless, repeated cyclical ischemic preconditioning can mitigate the reduction in blood oxygenation levels.

The drop in oxygen blood saturation level is an indication of the extent of oxygen deprivation and of a resulting "oxygen debt" owed to body tissue with high metabolic activity that has been under-supplied with oxygen. The degree of the oxygen debt or deprivation depends on the intensity and duration of total stress in relation to the level of blood oxygenation. Ischemia in a given type of body tissue (e.g., myocardium, lung tissue, skeletal-muscle tissue, etc.) can correspond to blood oxygen saturation levels below a certain threshold level $I_{threshold}$ which depends on the type of the tissue. The oxygen debt created by high metabolic demand can naturally cause the individual to breathe more deeply and more rapidly (e.g., by panting) in an attempt to restore blood oxygen saturation levels even as demand for oxygen decreases during relaxation periods (e.g., periods 323). Blood saturation levels may recover during the periods of rest (e.g., periods 324 and 325) accompanied by a return to normal (resting) breathing rates.

Now considering cycles 312 and 313, both cycles as illustrated in FIG. 3 have higher peak heart rates than earlier cycles 310 and 312. Thus, metabolic demand for oxygen is likely to be higher during cycles 312 and 313 than for earlier cycles 310 and 311. Further, breathing regimen 400 by requiring the individual to pause breathing (for duration T_{pause}) during the stress portion of cycle 312 (and also for the stress portion of cycle 313) prevents re-oxygenation of the blood during the periods of increased metabolic demand. As shown in FIG. 5 blood oxygen saturation levels drop to levels 540 and 550 for cycles 312 and 313, respectively. Ischemia results when blood oxygen saturation levels drops below ischemic threshold 580 (e.g., $I_{threshold}$ (myocardium)). For example, level 550 corresponding to cycle 313 is below threshold 580. Rapid panting may be naturally induced or encouraged by the severe lack of oxygen that is represented by levels 540 and 550. Periods 413 shown in FIG. 4 indicate rapid panting caused by severe lack of oxygen. The ischemia persists for a duration T_{isc} until renewed breathing coupled with reduced metabolic demand in period 325 restores the blood oxygen saturation level to values above threshold 580.

One ischemic "incident" is shown for purposes of illustration in FIG. 5. Optimal ischemic preconditioning can require one or more such ischemic incidents separated by suitable time intervals. By analyzing the individual's physiological parameters, breathing exercise regimens can be individually tailored to provide an optimal number of

ischemic incidents of specific duration T_{isc} separated by suitable time intervals to provide optimal ischemic preconditioning without tissue damage or necrosis. The breathing cycle parameters such as T_{in} , T_{hold} , T_{exh} , and T_{pause} , and stress-relaxation cycle parameters such as period 322 and target heart rates can be tailored to provide ischemic incidents of sufficient intensity and duration to generate biochemical and cellular chemistries that promote ischemic preconditioning. Additionally, the ischemic incidents can correspond to ischemic thresholds that correspond to specific tissues such as myocardial tissue, brain tissue, lung tissue, kidney tissue, skeletal-muscle, etc., and any combination thereof.

The traces of FIGS. 3, 4, and 5 are shown for purposes of illustration as if the physiological responses to exercise stress-relaxation cycles occur in isolation of other physiological phenomena. It will be appreciated, however, that in reality several exogenous and endogenous phenomena are superimposed. The total stress endured by an individual represents superimposed stress due a variety of sources, for example, aerobic physical activity, anaerobic physical activity, heart wave activity, internal body functions, body temperature, blood pressure, and internal circadian wave activity. FIG. 6 shows, for example, a circadian heart wave plotted on a time scale, the circadian wave C rising in amplitude to a peak C_p at about 6:00 p.m. Between 6:00 a.m. and 6:00 p.m. three ultradian waves V1, V2, and V3 are produced, the first taking place early in the morning, the second in the late morning, and the third in the afternoon.

In FIG. 6 heart waves generated during three exercise sessions (similar to that illustrated in FIG. 2) are shown superimposed as HW1, HW2, and HW3. The exercise regimens of the present invention can account for the total varying stress levels in generating, for example, stress-relaxation cycle parameters such as period 322 and target heart rates for optimal ischemic preconditioning. It should be noted that the temperature of the environment in which a subject is exercising may be adjusted to increase or decrease the amplitude and/or frequency of the heart waves.

Further, as described in Dardik, U.S. Pat. No. 5,810,737, the three illustrated exercise sessions HW1, HW2, and HW3 are synchronized with the ultradian waves and circadian waves to optimize the beneficial effect of cyclical exercise techniques. Similarly, the breathing regimens of the present invention can be designed and synchronized with ultradian waves, circadian waves, and other cyclical endogenous or exogenous phenomena. The synchronization can enable biochemical and cellular chemistries resulting from ischemic incidents in an exercise session to entrain, for example, on circadian waves so that ischemic preconditioning can be effective at times later than the incidents themselves.

Another aspect of the present invention relates to obtaining the benefits of ischemic pre-conditioning without ischemia, such as non-ischemic myocardial tolerance that results from increased oxygen demand. Oxygenating phases corresponding to rapid or panting breathing rates (e.g., as shown in breathing regimen 400, FIG. 4) can be co-ordinated to correspond to periods of high oxygen demand in body tissue. In addition to increasing oxygen demand in body tissue by physical exercise, high oxygen demand can be triggered by the breathing regimen itself. For example, a deep breath causes an individual's heart rate to substantially fluctuate (indicating substantially increased and decreased demand for oxygen in the myocardium). Breathing exercise regimens may be individually tailored to provide a suitable

number of high oxygen demand incidents (herein non-ischemic incidents) that increase myocardial tolerance.

Hereto, the present description illustrates the use of breathing exercise regimens to generate ischemic incidents and non-ischemic incidents separately. It will be appreciated, however, that in accordance with the present invention, the exercise treatments may consist of either one or both kinds of incidents. Either one or both kinds of incidents can be generated within an exercise session, for example, by using a breathing regimen that coordinates oxygenating phases with some periods of high oxygen demand to generate non-ischemic incidents, and co-ordinates non-oxygenating phases with other periods of high oxygen demand to generate ischemic incidents.

Methods of exercising according to the invention are also provided.

A preferred embodiment of a method according to the invention is shown by the flow chart 700 in FIG. 7. Box 710 shows a step of varying exertion during an exercise between a peak exertion (high) and a valley exertion (low). This varying creates an exercise program that increases heart rate variability and preferably substantially improves health.

Box 720 shows regulating the intake of oxygen during the varying. It should be noted that the regulating can be implemented at any point during the varying to obtain the benefits of the invention.

The regulating of the oxygen intake may include either depriving oxygen from the subject exercising or exaggerating his oxygen intake, e.g., by placing him in a relatively oxygen-rich environment.

This regulation may also be preferably implemented in periodic or cyclical fashion. In this way, waves are created in the heart function such that heart rate variability and other characteristics of the heart are improved.

The heart rate variability is improved because the cyclical regulation causes the myocardial oscillatory chemistry to swing up and down, thereby augmenting the heart rate variability already set in motion by the varying of the exertion shown in Box 710. The result of this is that the myocardium is substantially protected because of the heightened heart rate communication, organization and coherence of the waves in the heart.

FIG. 8 shows a more detailed flow chart of the method according to the invention. In this method, box 830 indicates a monitoring of the heart rate of an individual subject. Box 835 represents analyzing monitored data to determine breath regulation windows or sequences. Box 840 shows feeding back information in order to communicate the breath regulation windows to the subject. This may be accomplished through an audio or an audio/video feedback mechanism.

It is generally preferable to implement oxygen deprivation proximal to the end of an exercise session. Thus, in an exemplary exercise session(s), each session preferably including six cycles of variation in the heart rate, it may be preferable to regulate oxygen during a portion of the last two or three cycles. The length of the oxygen regulation depends on the health and endurance of the subject and should be determined with the aid of a knowledgeable professional.

FIG. 9 shows an alternative embodiment of the invention wherein box 960 indicates that the oxygen regulation should preferably be implemented at different heart rate ranges (e.g., 100-120, 110-130, 120-140 beats/min, etc.) determined at box 950. This provides pre-conditioning to the heart across a range of heart rates. One possible advantage obtained by such a method includes pre-conditioning an athlete to have potentially advantageous cardiac characteristics across an entire range of heart rates. Therefore, when

the athlete is performing at a high heart rate, he possesses a reservoir of positive cardiac response. This reservoir serves to help overcome the obstacles of high heart rate/extreme oxygen requirement intervals.

In yet another embodiment of the invention, the periodic oxygen regulation can be used with weight training. In this embodiment, the maximum strength output periods can be established by using oxygen regulation. For example, the oxygen regulation can be repeated in a particular time of the day, e.g., the late afternoon, such that a wave is created in the subject which provides maximum strength output in the period of the oxygen regulation, i.e., in the late afternoon.

As used herein, electronic networks could include a local area network, a wireless network, a wired network, a wide area network, the Internet, and any combination thereof. An electronic network can provide links to user interfaces (e.g., interface 60, FIG. 1) used for sending or receiving data. The interfaces can be any one or more of commercially available interface devices such as a web page, a web browser, a plug-in, a display monitor, a computer terminal, a modem, an audio device, a tactile device (e.g., vibrating surface, etc.), or any combination thereof.

In accordance with the present invention, software (i.e., instructions) for controlling the aforementioned apparatus can be provided on computer-readable media. It will be appreciated that each of the steps (described above in accordance with this invention), and any combination of these steps, can be implemented by computer program instructions. These computer program instructions can be loaded onto a computer or other programmable apparatus to produce a machine, such that the instructions which execute on the computer or other programmable apparatus create means for implementing the functions specified in the flowchart block or blocks. These computer program instructions can also be stored in a computer-readable memory that can direct a computer or other programmable apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means which implement the function specified in the flowchart block or blocks. The computer program instructions can also be loaded onto a computer or other programmable apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

It will be understood that the foregoing is only illustrative of the principles of the invention, and that various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention.

I claim:

1. A method of ischemically preconditioning an individual, said method comprising subjecting said individual to an exercise treatment according to a breathing exercise regimen, said breathing exercise regimen comprising:

at least one stress-relaxation cycle; and

at least one breathing cycle co-ordinated with said stress-relaxation cycle to induce at least one period of ischemia, wherein a method for generating said breathing exercise regimen comprises:

monitoring at least one physiological parameter of said individual indicative of ischemia; and

analyzing said at least one parameter to generate said breathing exercise regimen that is designed to induce at least one period of ischemia, wherein said analyzing

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generates said breathing exercise regimen that comprises a sequence of at least one breathing cycle coordinated with at least one stress-relaxation cycle of a first duration, and wherein said at least one breathing cycle comprises:

at least one exhalation of a second duration; and
at least one inhalation of a third duration, wherein said analyzing generates said at least one breathing cycle that further comprises at least one pause of a fourth duration.

2. The method of claim 1 wherein said analyzing further comprises coordinating said at least one breathing cycle with said at least one stress-relaxation cycle to induce said at least one period of ischemia for a fifth duration, wherein said fifth duration depends on said first, second, third, and fourth durations and on a varying level of stress in said stress-relaxation cycle, and wherein said analyzing further comprises designing said fifth duration so that biochemical and cellular chemistries that promote ischemic preconditioning are produced during said ischemic period.

3. The method of claim 2 wherein said varying level of stress represents superimposed stress due to at least one source that is selected from a group of sources consisting of aerobic physical activity, anaerobic physical activity, heart wave activity, internal body functions, internal circadian wave activity, and any combination thereof.

4. The method of claim 3 wherein said individual has an internal circadian wave activity having a period, and wherein said analysis generates said exercise breathing regimen that is synchronized with said circadian wave and such that said first, second, third, forth, and fifth durations are designed to cause said biochemical and cellular chemistries to entrain on said circadian wave so that said ischemic preconditioning is effective at later times that are multiples of said circadian period.

5. The method of claim 1 wherein said analyzing generates said breathing regimen wherein first greater than sum of said second and fourth durations.

6. The method of claim 1 wherein said analyzing generates said breathing regimen wherein first duration is comparable to sum of said second and fourth durations.

7. The method of claim 1 wherein said analyzing generates said breathing regimen wherein first duration is smaller than sum of said second and fourth durations.

8. A method of ischemically preconditioning an individual, said method comprising subjecting said individual to an exercise treatment according to a breathing exercise regimen, said breathing exercise regimen comprising:

at least one stress-relaxation cycle, said stress-relaxation cycle being of a first duration; and

at least one breathing cycle co-ordinated with said stress-relaxation cycle to induce at least one period of ischemia, wherein a method for generating said breathing exercise regimen comprises:

monitoring at least one physiological parameter of said individual indicative of ischemia; and

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analyzing said at least one parameter to generate said breathing exercise regimen that is designed to induce at least one period of ischemia, wherein said analyzing generates said breathing exercise regimen that comprises:

at least one oxygenating phase of breathing states selected from the group of states consisting of an inhalation, a pause, a hold, and any combination thereof, said oxygenating phase corresponding to a first period during which blood is oxygenated;

at least one non-oxygenating phase of breathing states selected from the group of states consisting of an exhalation, a pause, a hold, and any combination thereof, said non-oxygenating phase corresponding to a second period during which said which blood is not oxygenated; and

said phases are co-ordinated with said at least one stress-relaxation cycle.

9. The method of claim 8 wherein said analyzing generates said breathing exercise regimen wherein during said at least one non-oxygenating phase said individual's oxygen saturation level decreases below an ischemic threshold for at least one period of ischemia.

10. The method of claim 9 wherein said analyzing generates said breathing exercise regimen wherein said at least one ischemic period is designed to produce biochemical and cellular chemistries that promote ischemic preconditioning.

11. The method of claim 9 wherein said analyzing generates said breathing exercise regimen wherein said at least one ischemic period depends on a varying level of stress in said stress-relaxation cycle.

12. The method of claim 11 wherein said varying level of stress represents superimposed stress due to at least one source that is selected from a group of sources consisting of aerobic physical activity, anaerobic physical activity, heart wave activity, internal body functions, internal circadian wave activity, and any combination thereof.

13. The method of claim 12 wherein said individual has an internal circadian wave activity that has a period and wherein said analyzing generates breathing exercise regimen with said at least one period of ischemia designed to cause said biochemical and cellular chemistries to entrain on said circadian wave so that said ischemic preconditioning is effective at later times that are multiples of said circadian period.

14. The method of claim 8 wherein said analyzing generates said breathing exercise regimen wherein said at least one period of ischemia is greater than said first duration.

15. The method of claim 8 wherein said analyzing generates said breathing exercise regimen wherein said at least one period of ischemia is comparable to said first duration.

16. The method of claim 8 wherein said analyzing generates said breathing exercise regimen wherein said at least one period of ischemia is smaller than said first duration.

* * * * *

专利名称(译)	用于呼吸运动方案以促进缺血预处理的系统和方法		
公开(公告)号	US7338410	公开(公告)日	2008-03-04
申请号	US10/745769	申请日	2003-12-23
[标]申请(专利权)人(译)	LIFEWAVES INT		
申请(专利权)人(译)	LIFEWAVES INTERNATIONAL , INC.		
当前申请(专利权)人(译)	DARDIK欧文		
[标]发明人	DARDIK IRVING I		
发明人	DARDIK, IRVING I		
IPC分类号	A63B23/18 A61N1/00 A63B24/00 A61B5/00 A61B5/0205 A61B5/145 A61B5/22 A61M1/10 A61M16/00 A63B69/00 G06Q50/00		
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摘要(译)

提供了用于促进个体缺血预处理的系统和方法。缺血预处理由运动治疗提供。运动治疗包括呼吸运动方案，呼吸顺序为氧合和非氧合阶段，与压力 - 放松循环相协调。呼吸序列被设计用于诱导缺血期。个体化的运动治疗可以通过合适的间隔诱导最佳数量的局部缺血，以提供有效的缺血预处理。

