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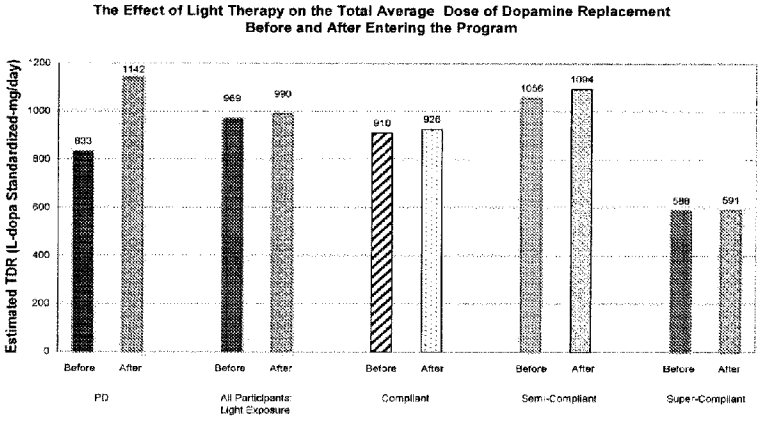

(57) Abrégé/Abstract:
Methods for preventing or treating motor-related neurological conditions include using ocular light therapy in connection with a conventional therapy for a motor-related neurological condition, such as a drug regimen, to adjust levels of melatonin and/or dopamine in the body of a subject. The ocular light therapy may include elevated levels of blue-green light or green light (e.g., light within a wavelength range of 460 nm to 570 nm, 490 nm to 570 nm, about 520 nm to 570 nm, etc.). The ocular light therapy may also include reduced levels of amber, orange and/or red light. Methods for diagnosing motor-related neurological conditions include use of ocular light therapy to cause a subject to temporarily exhibit one or more symptoms of any motor-related neurological condition to which the subject is predisposed, or which the subject may already be experiencing. A temporary increase in such symptoms may be effected by ocular administration of light including increased amounts of amber, orange and/or red light.

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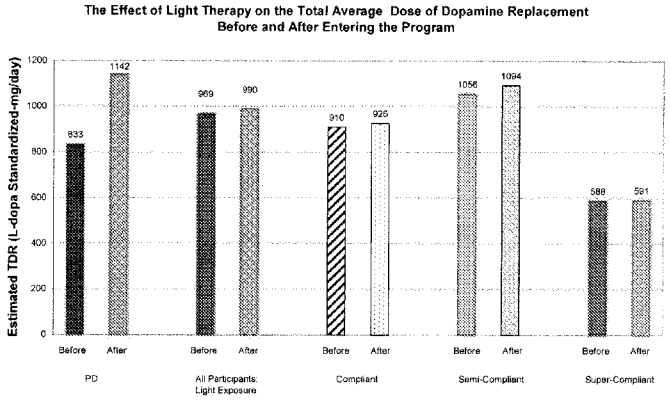

Fig. 18

(57) **Abstract**: Methods for preventing or treating motor-related neurological conditions include using ocular light therapy in connection with a conventional therapy for a motor-related neurological condition, such as a drug regimen, to adjust levels of melatonin and/or dopamine in the body of a subject. The ocular light therapy may include elevated levels of blue-green light or green light (*e.g.*, light within a wavelength range of 460 nm to 570 nm, 490 nm to 570 nm, about 520 nm to 570 nm, etc.). The ocular light therapy may also include reduced levels of amber, orange and/or red light. Methods for diagnosing motor-related neurological conditions include use of ocular light therapy to cause a subject to temporarily exhibit one or more symptoms of any motor-related neurological condition to which the subject is predisposed, or which the subject may already be experiencing. A temporary increase in such symptoms may be effected by ocular administration of light including increased amounts of amber, orange and/or red light.

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METHODS FOR PREVENTING AND TREATING MOTOR-RELATED NEUROLOGICAL CONDITIONS

TECHNICAL FIELD

The present invention relates generally to methods for preventing or treating motor-related neurological conditions and, more specifically, to methods that include stimulating a dopaminergic response by the body of a subject, which may include adjusting levels of one or more of monoamines, such as melatonin, dopamine and serotonin and/or their analogs or derivatives within the body of a subject to reduce or eliminate primary and/or secondary symptoms of a motor-related neurological condition, or to prevent or treat a motor-related neurological condition. In particular embodiments, the present invention relates to the use of light therapy in combination with one or more traditional therapies for adjusting levels of melatonin and/or melatonin analogs and/or levels of dopamine and/or dopamine derivatives in a manner that reduces or eliminates symptoms of a motor-related neurological condition, halts the progression of a degenerative neurological disease, or prevents or treats a motor-related neurological condition. In embodiments of the present invention, light therapy may be used in conjunction with drug therapy for addressing motor-related neurological conditions.

BACKGROUND OF RELATED ART

Motor-related neurological conditions, which are also referred to as "movement disorders," and other neuropsychiatric disorders typically result from the degeneration of neurons in the central nervous system. As neurons degenerate, their ability to convey or otherwise utilize neurotransmitters may diminish, a phenomenon known in the art as "decreased amine function." In particular, in subjects that suffer from Parkinson's disease and many other motor-related neurological conditions, the

degeneration of neurons of the so-called "nigro-striatal dopamine" (NSD) system results in a decrease in the ability of these neurons to transmit dopamine, decreasing the ability of neurons of the NSD system to communicate with adjacent neurons. This disruption in communication results in loss of motor control, which is typically progressive and permanent.

Efforts to counteract the loss of motor control include the administration of dopamine precursors, dopamine analogs and enzyme-modifying drugs (*e.g.*, L-dopa, etc.), which act like dopamine without decreasing the natural production of dopamine. By providing the remaining functional neurons of the NSD system with dopamine analogs, the rate at which these neurons can communicate may increase, which may artificially restore at least some of the lost motor control experienced by subjects that suffer from motor-related neurological conditions.

SUMMARY

The present invention includes methods for reducing or eliminating symptoms of motor-related neurological conditions, or for preventing or treating motor-related neurological conditions. Methods that incorporate teachings of the present invention may be useful in conjunction with traditional therapies (*e.g.*, the administration of drugs, etc.), and may reduce the extent of traditional therapies (*e.g.*, the dosages of drugs, etc.) that are needed to address motor-related neurological conditions "Motor-related neurological conditions," as used herein, includes both primary motor-related neurological conditions, as well as secondary conditions, or symptoms, that may accompany or result from a primary motor-related neurological condition. The terms "address" and "addressing," when used in connection with "motor-related neurological conditions," refer to reducing or eliminating symptoms of a motor-related neurological condition, as well as prevention and treatment of the motor-related neurological condition itself.

In various embodiments, a method according to the present invention may include addressing a motor-related neurological condition by stimulating a dopaminergic response by a subject's body and/or adjusting levels of one or more monoamines, such as melatonin, dopamine, serotonin, and their analogs and/or derivatives, within the subject's body. For the sake of simplicity, the term "melatonin," as used herein, includes melatonin and analogs of melatonin, while the

term "dopamine" includes dopamine and dopamine analogs, derivatives and other dopamine substitutes and the term "serotonin" includes serotonin and derivatives and analogs thereof. In some embodiments, a method according to the present invention includes addressing (*e.g.,* adjusting, etc.) levels of one or more of melatonin, serotonin and dopamine in a subject's body.

Amounts or levels of one or more monoamines (*e.g.,* melatonin, serotonin and/or dopamine, etc.) within the body of a subject may be adjusted in a manner that addresses a motor-related neurological condition. The term "adjustment," as used herein, includes adjusting levels of monoamines in the body of a subject. The adjustment of one or both of melatonin and dopamine levels in the body of a subject is also referred to herein as "melatonin-dopamine adjustment." Melatonin-dopamine adjustment within the body of a subject may be achieved by regulating production of melatonin. As used herein, "regulating" and similar terms include, but are not limited to, reducing melatonin levels and/or levels of dopamine, as well as moderating levels of melatonin and/or dopamine to adjust a subject's melatonin-dopamine profile.

A dopaminergic response may be stimulated in a variety of ways, such as by administering light to the eyes of a subject, a practice that is also referred to as "ocular light therapy." In various embodiments, ocular light therapy may include the administration of light including, consisting essentially of, or consisting of blue-green light and/or green light (*e.g.,* light within a wavelength range of 460 nm to 570 nm, 490 nm to 570 nm, about 520 nm to 570 nm, about 555 nm, etc.) to the subject. In some embodiments, above-ambient levels (*e.g.,* irradiance, or energy; photon density; intensity; etc.) of blue-green and/or green light may be provided to the subject's eyes.

In some embodiments, levels of amber, orange and/or red wavelengths of light (*e.g.,* visible light having wavelengths of greater than 570 nm, visible light having wavelengths of greater than 570 nm to about 750 nm, etc.) administered to a subject may be less than the levels of blue-green and/or green wavelengths in the administered light. In other embodiments, the levels (*e.g.,* irradiance, or energy; photon density; intensity; etc.) of blue-green and/or green light administered to a subject may exceed the corresponding levels of amber, orange and/or red light administered to the subject. In some embodiments, the levels of amber, orange and/or red light administered to a subject may be at most about half the levels of blue, blue-green and/or green light that are administered to the subject. Alternatively, or in

addition, levels of one or more of amber, orange and red wavelengths of light may simulate or fall below the levels of amber, orange and/or red wavelengths of light that are present in standard indoor lighting, or the "ambient" densities of one or more of amber, orange and/or red wavelengths of light for any particular narrow band isolated intensity present in ambient light to which a subject is normally exposed, etc.).

By administering ocular light therapy in accordance with one or more of the teachings above, monitoring a subject's condition and response to ocular light therapy, and adjusting one or both of the ocular light therapy and drug therapy administered to the subject, the subject's dopaminergic response may be stimulated, which may vary monoamine (*e.g.,* melatonin, dopamine and/or serotonin, etc.) levels in the body of the subject, in a manner that addresses a motor-related neurological condition. In some embodiments, such administration, monitoring and adjustment may include a reduction in traditional therapies (*e.g.,* the dosages of drugs, such as dopamine derivatives and/or drugs for addressing the side-effects of dopamine derivatives, etc.) that have been used to address the motor-related neurological condition. In some embodiments, the amounts of one or more monoamines in the subject's body or produced by the subject at one or more particular times during the day may be adjusted. In other embodiments, the amounts of one or more monoamines present within the subject's body or produced by the subject throughout the day, or one or more parts of the subject's monoamine profile, may be antagonized, moderated or manipulated. In a more particular embodiment, one or more parts of the subject's monoamine profile may be antagonized, moderated or manipulated to resemble a "normal" monoamine profile; *e.g.,* the monoamine profile of a healthy subject, of a subject that does not suffer from a motor-related neurological condition, or the subject's monoamine profile during an earlier time of day. Moderation of a subject's monoamine profile may include administration of dopaminergic stimulation therapies or monoamine regulation therapies (*e.g.,* light therapy, etc.) at one or more times each day.

In one aspect, the present invention includes, consists essentially of or even consists of the use of light therapy methods for preventing or treating at least one motor-related neurological condition. Examples of such conditions include, but are not limited to, Huntington's chorea, periodic limb movement syndrome, restless leg syndrome, nocturnal myoclonus, Tourette's syndrome, Sundowner's syndrome, REM

Sleep Behavior Disorder, schizophrenia, Pick's disease, Punch drunk syndrome, progressive subnuclear palsy, multiple systems atrophy, corticobasilar degeneration, vascular Parkinsonism, Lewy body dementias, diffuse Lewy body disease, Parkinson's plus syndrome, Korsakow's (Korsakoff's) syndrome, multiple sclerosis, medication-induced motor disorders, drug-induced Parkinson's disease, neuroleptics-induced Parkinson's disease, acute dystonia, stroke-post ischemic Parkinsonism, trans-ischemic attack, akathesia dyskinaesia and tardive dyskinaesia. Disorders characterized by features that typify those expressed as secondary symptoms in Parkinson's disease patients and other diseases in which dopamine, serotonin or noradrenaline function is altered may also be treated in accordance with teachings of the present invention. Nonlimiting examples of secondary symptoms include Alzheimer's disease, dementia, depressive pseudo dementia, hydrocephailic dementia, dementia associated with Parkinson's disease, anxiety, generalized anxiety disorder, panic disorder, agoraphobia, obsessive-compulsive disorder, post-traumatic stress disorder, acute stress disorder, depression, bipolar disorder, various personality and insomnia disorders.

In another aspect, the present invention includes the use of light therapy in conjunction with traditional therapies for motor-related neurological conditions. Thus, light therapy may be used in conjunction with drug treatment, cellular (*e.g.,* fetal cell, stem cell, etc.) therapies, surgical treatments and/or other therapies for addressing motor-related neurological conditions. Ocular light therapy may be administered in conjunction with melatonin agonists or antagonists to adjust a subject's melatonin levels.

The present invention also includes systems in which light therapy apparatuses are used in conjunction with traditional therapies.

Use of light therapy to stimulate a dopaminergic response by a subject's body, which may affect monoamine (*e.g.,* melatonin-dopamine, etc.) adjustment in the body of a subject, in conjunction with monitoring of the subject's response to the light therapy, may also enable a physician to reduce a dosage of one or more drugs prescribed for and administered to a subject suffering from a motor-related neurological condition, while, in some instances, having a disease-modifying effect (*e.g.,* slowing or halting progression of the condition, etc.). The course of treatment for a particular subject that suffers from a motor-related neurological condition may

be revised to decrease the need for conventional treatment of the motor-related neurological condition (*e.g.*, to decrease the dosage of one more drugs (*e.g.*, a dopamine analog, an analog of another neurotransmitter, etc.), etc., administered to that subject). In some embodiments, when light therapy is used in conjunction with drugs to treat a motor-related neurological condition, a physician may prescribe a lower-than-normal dosage of the drugs (*i.e.*, a lower-than-normal dosage of a drug that is typically required when monoamine production (*e.g.*, melatonin production, etc.) is not regulated). When light therapy is coupled with drug therapy, a physician may define a succinct and strategic controlled therapy package that, in some cases, may be tailored to a particular subject.

In another aspect, the present invention includes standardization among various dopamine replacement therapies and as to how much of any various dopamine replacement therapies any given patient should receive. For example, a daily dosage of 1000 mg of one medication may be the equivalent of a 650 mg daily dosage of another medication. Because the use of light therapy in accordance with teachings of the present invention enables a reduction in dosages of dopamine replacement medication, a drug conversion table may be used to standardize equivalent doses for various dopamine replacement medications. In this way, an effective reduction in the required dosage of a dopamine replacement medication can be achieved regardless of the medicine used. Such a table, titled a "Total Drug Burden" or "TDB" table, is provided in FIG. 21.

The present invention also includes techniques for diagnosing motor-related neurological conditions. In such a technique, increased levels of one or more of amber, orange and red light may be administered to a subject. In some embodiments, the colors and intensities of light administered to the subject may be about the same as or greater than levels of the same color or colors of light present at dusk. The light may be administered ocularly. Administering one or more of amber, orange and red light to the subject may cause the subject to temporarily exhibit symptoms of one or more motor-related neurological conditions before such symptoms would otherwise present themselves. The discovery of such conditions following the administration of amber, orange and/or red light in accordance with teachings of the present invention may enable a physician to make a pre-diagnosis or an early diagnosis of a motor-related neurological condition. In the event that a physician determines that the

subject is likely to suffer or will suffer from a motor-related neurological condition, the physician may prescribe a course of treatment for the diagnosed condition. A prescribed course of treatment may include, among other things, use of suitable ocular light therapy, etc., the administration of one or more drugs, and/or other suitable treatments.

Other aspects, as well as features and advantages of various aspects, of the present invention will become apparent to those of ordinary skill in the art through consideration of the ensuing description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIGs. 1-4 are charts illustrating the effects of various treatment regimens that incorporate teachings of the present invention on subjects that suffer from motor-related neurological conditions;

FIG. 5 illustrates the actions of a subject during a fist to elbow latency test;

FIG. 6 illustrates the actions of a subject during a knee to floor latency test;

The charts of FIGs. 7-15 depict the effects of long-term light therapy on the symptoms of subjects who suffer from motor-related neurological conditions – specifically demonstrating that when light therapy and drug therapy are combined, the progression of degenerative neurological diseases may be slowed or halted;

FIGs. 16 and 17 are charts illustrating the effects of long-term light therapy—specifically, light predominantly including a narrow band isolated intensity of green light—on subjects who suffer from motor-related neurological conditions;

FIG. 18 is a chart that compares the average drug dosages required by subjects who suffer from motor-related neurological disorders at the outset of a prolonged light therapy study to the average drug dosages required by the subjects at the end of the prolonged light therapy study;

FIGs. 19 and 20 are charts demonstrating the utility of red light in enabling the early diagnosis of motor-related neurological conditions; and

FIG. 21 is a chart depicting equivalent dosages for a variety of dopamine derivatives.

DETAILED DESCRIPTION

Ambient light provides a reference point for the manner in which light may be administered to a subject in accordance with teachings of the present invention. The phrase "ambient light" refers to an amount or level of light, such as an intensity, a photon density, or an irradiance, or energy, of light. "Ambient light" may refer to a collection of wavelengths of visible light, such as those present in so-called "white light," which is more accurately referred to as "polychromatic light," or in narrower bandwidths (*e.g.,* colors, etc.) of light. As will become more apparent from the ensuing description, it may be beneficial in some embodiments of the present invention to expose a subject to above-ambient levels of some wavelengths of light, while limiting the subject's exposure to other wavelengths of light to below-ambient levels.

As used herein, the phrase "ambient level" may refer to an average of the level or amount of a particular bandwidth of light in ambient indoor lighting. Standard indoor lighting is generally white light, or polychromatic light, having an intensity of about 50 lux to about 500 lux. Ambient indoor lighting may comprise standard indoor fluorescent lighting or standard indoor incandescent lighting.

The "average" level or amount of light of a particular bandwidth may include an average of the level or amount of that bandwidth in ambient indoor lighting at about 50 lux and the level or amount of that bandwidth in ambient indoor lighting at about 500 lux. Levels of various bandwidths of light may be considered to be "above-ambient" when they exceed the ambient levels of the same wavelengths of light present in ambient indoor lighting. Conversely, levels of various wavelengths of light are considered to be "below-ambient" when they are less than the ambient levels of the same wavelengths of light present in the same type of ambient indoor lighting.

As a point of reference, standard incandescent indoor lighting, which has a collective ambient intensity of about 50 lux to about 500 lux, is composed primarily of amber and red wavelengths of light, with some green light, which makes up only a small portion of the spectrum output by standard incandescent indoor lighting. Standard fluorescent indoor lighting has the signature of mercury, with three peaks: a first peak in the indigo-deep blue range (435 nm-436 nm); a second peak in the green-yellow range (540 nm-560 nm); and a third peak at the red wavelength of 640 nm. The deep blue and green-yellow peaks of such light are, of course, less

intense, photon-dense or luminescent, or energetic, than the collective intensity of light output by standard fluorescent indoor lighting.

At about 50 lux, standard indoor lighting (incandescent and/or fluorescent) has a collective photon density of 3.70×10^{13} photons/cm^2/s and a collective irradiance of 13.2 μW/cm^2 (or 1.32×10^{-5} W/cm^2). The blue-to-green (*e.g.*, 460 nm to 570 nm, etc.) portion of the spectrum of about 50 lux standard indoor lighting has a photon density of 1.35×10^{13} photons/cm^2/s and an irradiance of 5.1 μW/cm^2. These values, as well as the photon density and irradiance of narrower wavelength ranges in the blue-to-green in standard indoor lighting having an intensity of about 50 lux, are included in the following table:

TABLE 1

Standard Indoor Light at About 50 lux			
Color/Wavelength Range	**Photon Density** (photons/cm^2/second)	**Irradiance** (μWatts/cm^2)	**Lux**
Polychromatic (white)	3.70×10^{13}	13.2	47
Blue (460 nm to 500 nm)	3.31×10^{12}	1.4	2
Green (500 nm to 570 nm)	1.03×10^{13}	3.8	22
Blue-to-Green (460 nm to 570 nm)	1.35×10^{13}	5.1	23
490 nm to 565 nm	1.02×10^{13}	3.8	20
520 nm to 565 nm	7.25×10^{12}	2.6	17
525 nm to 555 nm	4.81×10^{12}	1.8	11
520 nm to 539 nm	2.68×10^{12}	1.0	6

The amber-to-red (*e.g.*, above 570 nm to 750 nm, etc.) portion of the spectrum of about 50 lux standard indoor lighting has an intensity of about 24 lux, a photon density of 2.04×10^{13} photons/cm^2/s and an irradiance of 6.7 μW/cm^2. The irradiance of amber-to-red light in standard indoor lighting at about 50 lux exceeds the irradiance of the blue-to-green "effective" spectrum of standard indoor lighting at about 50 lux.

At about 500 lux, the collective photon density of standard indoor lighting is 3.69×10^{14} photons/cm^2/s and the collective irradiance of standard indoor lighting is 133.5 μW/cm^2. At about 500 lux, the blue-to-green portion of the standard indoor lighting spectrum has a photon density of 1.53×10^{14} photons/cm^2/s and an irradiance of 58.4 μW/cm^2. These values, as well as the photon density and irradiance of

narrower wavelength ranges in the blue-to-green in standard indoor lighting having an intensity of about 500 lux, are included in the following table:

TABLE 2

Standard Indoor Light at About 500 lux			
Color/Wavelength Range	**Photon Density** (photons/cm^2/second)	**Irradiance** (μWatts/cm^2)	**Lux**
Polychromatic (white)	3.69×10^{14}	133.5	479
Blue (460 nm to 500 nm)	4.09×10^{13}	16.9	18
Green (500 nm to 570 nm)	1.14×10^{14}	42.0	238
Blue-to-Green (460 nm to 570 nm)	1.53×10^{14}	58.4	256
490 nm to 565 nm	1.15×10^{14}	42.9	223
520 nm to 565 nm	7.79×10^{13}	28.5	181
525 nm to 555 nm	5.14×10^{13}	18.9	121
520 nm to 539 nm	3.03×10^{13}	11.4	66

The amber-to-red portion of the spectrum of about 500 lux standard indoor lighting has an intensity of about 225 lux, a photon density of 1.85×10^{14} photons/cm^2/s and an irradiance of 60.4 μW/cm^2. The irradiance of amber-to-red light in standard indoor lighting at about 500 lux exceeds the irradiance of the blue-to-green "effective" spectrum of standard indoor lighting at about 500 lux.

Based on the foregoing, when "ambient" includes an average of the level of one or more bandwidths of light in polychromatic light of about 50 lux and the level of the same bandwidth(s) of light in polychromatic light of about 500 lux, the ambient levels of the bandwidths set forth in TABLES 1 and 2 may include the ambient values for standard indoor lighting identified in TABLE 3.

TABLE 3

Average Ambient Levels of Standard Indoor Light			
Color/Wavelength Range	**Photon Density** (photons/cm^2/second)	**Irradiance** (μWatts/cm^2)	**Lux**
Polychromatic (white)	2.03×10^{14}	73.4	263
Blue (460 nm to 500 nm)	2.21×10^{13}	9.1	10
Green (500 nm to 570 nm)	6.19×10^{13}	22.9	130
Blue-to-Green (460 nm to 570 nm)	8.35×10^{13}	31.8	140
490 nm to 565 nm	6.24×10^{13}	23.4	122
520 nm to 565 nm	4.26×10^{13}	15.6	99

Average Ambient Levels of Standard Indoor Light			
Color/Wavelength Range	**Photon Density** (photons/cm^2/second)	**Irradiance** (μWatts/cm^2)	**Lux**
525 nm to 555 nm	2.81×10^{13}	10.3	66
520 nm to 539 nm	1.65×10^{13}	6.2	36

The amber-to-red portion of the spectrum of ambient standard indoor lighting has an intensity of about 125 lux, a photon density of 1.03×10^{14} photons/cm^2/s and an irradiance of 33.6 μW/cm^2. The irradiance of amber-to-red light in standard indoor lighting of average intensity exceeds the irradiance of the blue-to-green "effective" spectrum of standard indoor lighting at average intensity.

As an alternative to defining "ambient" in terms of an average, "ambient" light may include polychromatic light within a range of intensities, photon densities and/or irradiances, or energies, along with the levels of light within various bandwidths of polychromatic light within such a range. Levels of various wavelengths of light may be considered to be "above-ambient" when they exceed the same levels of the same wavelengths of light in an ambient range. Conversely, levels of various wavelengths of light may be considered to be "below-ambient" when they are less than the same levels of the same wavelengths of light present in the ambient range. For purposes of this disclosure, the low end of "ambient" levels may comprise the levels of each wavelength range present in about 50 lux polychromatic light, while the high end of "ambient" levels comprises the levels of various wavelength ranges present in about 500 lux polychromatic light. With this definition of ambient, below-ambient levels would include below-about 50 lux levels, while above-ambient levels would include above-about500 lux levels.

A method for addressing motor-related neurological conditions in accordance with teachings of this present invention includes administering light therapy to a subject who suffers from, is believed to be suffering from, or is at risk for a motor-related neurological condition. Light therapy may be administered in a manner that stimulates a dopaminergic response by the subject, which may adjust levels of one or more monoamines (*e.g.,* melatonin, serotonin, dopamine, etc.) in the body of the subject. The administration of light therapy may be conducted in conjunction with the administration of conventional therapies, including, but not limited to, the administration of dopamine derivatives or other drugs for addressing motor-related

neurological conditions. In addition to administering light therapy, a method of the present invention may include evaluating the effect of the light therapy on the subject's symptoms, if any. In cases where light therapy addresses the subject's symptoms, any conventional therapies used in conjunction with the light therapy may be adjusted (*e.g.,* decreased, etc.) in response to the effects of light therapy on the subject. The use of light therapy that incorporates teachings of the present invention, with or without conventional therapy for addressing motor-related neurological conditions, may stimulate a dopaminergic response by the subject's body, which, among other things, may adjust levels of one or more monoamines within the subject's body (*e.g.,* levels of melatonin in the body of a subject relative to dopamine levels in the subject's body, including levels of melatonin and dopamine within the brain of the subject, etc.).

Ocular light therapy may include the administration of light including blue-green and/or green wavelengths of light to the subject. In some embodiments, the light that is administered to the subject includes above-ambient levels of blue-green and/or green wavelengths. Light therapy that employs ambient or below-ambient levels of blue-green and/or green wavelengths is also within the scope of the present invention.

The blue-green and/or green light that is administered to the subject may be administered as blue-green light and/or green light or other types of light (*e.g.,* polychromatic light, etc.) that include above-ambient levels of green light or blue-green light, or light that is predominantly blue-green and/or green. Nonlimiting examples include colors of light with above-ambient levels of wavelengths that are within a wavelength range of 460 nm to 570 nm, 490 nm to 570 nm, about 520 nm to 570 nm, about 525 nm to about 555 nm, above 520 nm to less than 540 nm, or any wavelength within any of these ranges.

In some embodiments, a narrow portion of the spectrum of visible light may be administered to the subject. Without limiting the scope of the present invention, the light administered to the subject may consist essentially of (*i.e.,* with the possible addition of colors or wavelengths of visible light directly adjacent to a blue-green and/or green band) blue-green and/or green light, or consist of blue-green and/or green light.

Other embodiments of the method include administering blue-green and/or green light to the subject as part of light that comprises a plurality of different colors, or so-called "polychromatic light." In more specific embodiments, the polychromatic light may comprise so-called "white light." In some embodiments, including those where polychromatic light that includes a peak in the blue, blue-green and/or green wavelengths is delivered to a subject's eyes, the light may be delivered at an above-ambient intensity (including an intensity of about 500 lux or more, an intensity of about 1,000 lux or more, an intensity of about 1,500 lux or more, an intensity of about 4,000 lux or more, an intensity of about 5,000 lux or more, etc.).

Administration of polychromatic light may include omission of one or more wavelengths of light or elimination of one or more wavelengths from polychromatic light before the light reaches the subject's eyes, or is administered to the subject. In some embodiments, the elimination of one or more wavelengths of light from polychromatic light, including white light, may be accomplished by filtering. Filtering may reduce one or more colors or wavelengths of light to below-ambient levels (*e.g.,* to an intensity of about 50% or less of a combined intensity of therapeutic light, such as light having wavelengths of 460 nm to 570 nm, etc.). Alternatively, filtering may substantially remove, or even completely remove, one or more colors or wavelengths of light from the polychromatic light. Filtration of one or more wavelengths from polychromatic light may be based on any of a number of factors. One embodiment of a factor upon which filtering may be based is the undesirability of one or more wavelengths (*e.g.,* amber, orange, red, etc.).

Examples of undesirable wavelengths of light include wavelengths or colors of light that decrease the therapeutic effects of certain wavelengths of visible light (*e.g.,* by canceling or opposing the activating effects of the therapeutic wavelengths of visible light, etc.), wavelengths or colors of light that are known to enhance or exacerbate symptoms of one or more motor-related neurological conditions, wavelengths or colors of light that may interfere with a subject's ability to exhibit a dopaminergic response or disrupt the monoamine profile in the subject's body (*e.g.,* the subject's brain, etc.) (*e.g.,* the melatonin-dopamine balance in the subject's body,etc.), and even wavelengths or colors of light that provide no apparent benefit when administered to a subject who suffers from, is believed to suffer from, or is at risk for suffering from a motor-related neurological condition. It has recently been

found that light with wavelengths of light that are longer than those of green light (*e.g.*, light having wavelengths of greater than 570 nm, from greater than 570 nm to about 750 nm, amber, orange, and/or red wavelengths of light, etc.) enhance or exacerbate symptoms of motor-related neurological conditions.

The bandwidth of light that is reduced omitted or eliminated may comprise one or more of amber light, orange light and red light, or at least one wavelength of one or more the foregoing may be omitted or filtered. In more particular embodiments, visible light having wavelengths of greater than 570 nm, visible light having wavelengths of greater than 570 nm to about 750 nm, etc., may be filtered from polychromatic light prior to its administration to a subject. In some embodiments, when ambient or below-ambient levels of blue-green and/or green light are administered to a subject, the levels of blue-green and/or green light may exceed the levels of amber, orange and/or red wavelengths of light administered (*e.g.*, exceed a 1:1 ratio, by a ratio of about 2:1 or more, etc.).

The administration of light therapy to a subject in accordance with teachings of the present invention may be effected at one or more times during the day. In some embodiments, the light therapy may be administered at the same time or times, or substantially the same time or times, each day. The time or times of day at which light therapy is provided may be regulated, as may the intensity (*e.g.*, photon density, etc.) of one or more wavelengths of light administered to the subject.

Light therapy may be administered to the subject in accordance with an optimal dosing schedule. The optimal dosing schedule may, in some embodiments, include light therapy once a day. In some embodiments, the optimal dosing schedule for light therapy may include administering the light therapy in the evening (*e.g.*, at a time of day when melatonin levels are typically increasing, etc.). In a specific, but nonlimiting, embodiment, the optimal dosing schedule may include administration of light therapy an hour-and-a-half or more after the final administration of drugs to the subject during the day. In a more specific embodiment, light therapy may be administered between about 5:00 p.m and about 3:00 a.m. or, even more specifically, between about 7:00 p.m. and about 10:00 p.m. The intensity (*e.g.*, a photon density of about 10^{13} photons/cm^2/s to about 10^{16} photons/cm^2/s, etc.) and the duration (*e.g.*, about one hour, about thirty minutes, etc.) of the light therapy may be tailored to

reduce melatonin levels without adversely affecting the subject's sleep patterns, or circadian rhythms.

In other embodiments, light therapy may be administered at a plurality of different times throughout each day. The intensity and duration of each treatment may be tailored to provide a desired effect at a particular time during the day, with two or more of the treatments differing (*e.g.,* in color, intensity, duration, etc.) from one another. Alternatively, all of the light therapy treatments administered during the twenty-four (24) hour day may be the same as or substantially the same as (*i.e.,* with any variance attributable merely to unintended fluctuations in intensity, time, etc.) the other treatments administered during that day.

Light therapy in accordance with teachings of the present invention may slow or halt the progression of a motor-related neurological disorder after a few treatments, or positive results may not be seen until light therapy is administered for longer periods of time (*e.g.,* weeks, months, etc.). In any event, light therapy may be used as a long-term (*e.g.,* six months, years, the remainder of a subject's life, etc.) treatment.

In some embodiments, light therapy may be used alone to prevent or treat a motor-related neurological condition. Stated another way, treatment of the motor-related neurological condition may consist of light therapy.

Alternatively, light therapy may be administered in conjunction with the administration of one or more other treatments for motor-related neurological conditions. In some embodiments, these other treatments comprise traditional therapies, such as cellular therapies (*e.g.,* with fetal cells, stem cells, etc.), surgical treatments, and the like.

In embodiments where light therapy is administered to a subject in connection with drug therapy, or pharmacological treatment, the drugs may include medications intended for treatment of motor-related neurological conditions and/or the symptoms of such conditions. Non-limiting examples of such drugs include those that target the dopamine (DA), noradrenaline (NA) and serotonin (5HT) systems, as well as other drugs identified in FIG. 21. FIG. 21 illustrates the equivalent daily dosage ranges for a variety of dopamine replacement therapies, including daily dosages of such therapies that are considered to be low (between the first two continuous vertical lines), medium (between the second and third continuous vertical lines) and high (between the third and fourth continuous vertical lines). The added use of light therapy may

enable a physician to prescribe lower than normal dosages (*i.e.,* drug dosages that are typically required when melatonin production is not regulated) of these drugs to treat the diagnosed motor-related neurological condition. For example, a dosage of a particular dopamine replacement therapy that would normally (*i.e.,* without light therapy) be in the "high" range may, with light therapy in accordance with teachings of the present invention, be reduced to the "medium" or "low" range for the same drug, or to the "medium" or "low" range for another drug listed on the Total Drug Burden table. Similarly, the use of light therapy may enable a reduction in normally "medium" range dosages to dosages in the "low" range. Reducing the dosages of drug therapies may also reduce or eliminate the side-effects of the drugs, along with the need for additional drugs to treat any side-effects.

In some embodiments, the times at which drugs are administered in an optimal dosing schedule are distinct from the time or times of the day at which light therapy is administered. In a more specific embodiment, drug treatment in accordance with an optimal dosing schedule may occur during a first part of the day, while light therapy is administered during a second part of the day. For example, drugs may be administered during the day, while administration of light therapy occurs during the evening. In a more specific embodiment, drug administration may start sometime during the morning (*e.g.,* about thirty minutes before a subject's symptoms would otherwise (without taking the drugs) typically appear) and be complete by 5:30 p.m., while light therapy is administered between 7:00 p.m. and 10:00 p.m.

A number of specific embodiments of dosing and treatment methods are set forth in TABLES 7-13. In those embodiments, light therapy, in the form of polychromatic light having peaks at about 435nm to about 436 nm, about 460 nm to about 520 nm, about 540 nm to about 560 nm, and about 640 nm was administered at an intensity of about 1,000 lux to about 1,500 lux. The irradiance of the blue-green light present in the light administered to each subject was about 280 $\mu W/cm^2$, while the irradiance of the red light present in that light was only about 150 $\mu W/cm^2$. Although TABLES 7-13 provide many specifics, it should be understood that the details, particularly those concerning the use of polychromatic light (in reference to white light), its intensity, and the duration of the light therapy each day, pertain to specific embodiments of the disclosed protocols.

TABLE 7 sets forth a procedure by which light and drug (dopamine (DA) replacement, or DA agonist) therapies may be tailored for a new (*de novo*, or "DN") patient, who has been recently diagnosed with Parkinson's disease (PD).

TABLE 7

Rule	**Example Conditions for Photo-Pharmacological Intervention in A *de novo* Patient**
DN1. Commencing Dose	In *de novo* patients, the commencing dose should be 50 mg of levodopa twice daily at, for example, 10:00 a.m. and 4:00 p.m. If the patient's responsiveness to levodopa diminishes over time, the dose of levodopa can be increased to 50 mg three times per day, say at the 8:00 a.m., 1:30 p.m., and 5:30 p.m. If the therapeutic effect continues to diminish during the day, each dose may be increased by increments of ¼ to ½ at each administration.
DN2. First Dose	If a patient experiences a symptom-free period upon wakening, the first task is to identify the time when the PD symptoms first appear. The first dose of the day should then be administered approximately 30 minutes prior to the time identified. As this may change with continued phototherapy, the time of first dose should be adjusted accordingly.
DN3. Last Dose	The last daily dose of DA replacement should not occur any later than 5:30 p.m.
DN4. Optimal Frequency and Time of Dosing	Three doses of DA replacement per day: Example times of 8:00 a.m., 1:30 p.m., and 5:30 p.m.
DN5. Escalation to Ceiling dose.	Total daily dosage should peak at no more than 600 mg per day in three equally divided lots. If other DA replacement drugs are taken concomitantly, they should not exceed three doses.
DN6. Time of Phototherapy	Exposure to light should commence between the hours of 7:00 p.m. and 10:00 p.m. Drug regimens should not be altered until an observation period of 2-4 weeks has been undertaken and the patient is in compliance.
DN7. Duration of Phototherapy	The duration of phototherapy should last for 1 hour and should be undertaken daily.
DN8. Frequency and Intensity of Emission	The frequency of emission should be polychromatic light with an intensity of about 1,000 lux to about 1,500 lux.

In TABLE 8, a protocol for incorporating light therapy into an existing drug (pharmacological) treatment regimen is described.

TABLE 8

Rule	**Example Conditions for Photo-Pharmacological Intervention in A Patient Undergoing Pharmacological Treatment**
T1. Treatment Response Stabilization (TRS)	In patients that have been maintained on DA replacement therapy for at least two years, it is first important that the patient experience some stability in their therapeutic response to their drug regimen prior to commencing added treatment with light therapy. This requires professional assessment and stabilization for a period of time from 4-8 weeks.
T2. First Dose	If a patient experiences a symptom-free period upon wakening, the first task is to identify the time when the PD symptoms first appear. The first dose of the day should then be administered approximately 30 minutes prior to the time identified.
T3. Last Dose	The last daily dose of DA replacement should not occur any later than 5:30 p.m. A patient should not be woken to take medication. If dosing occurs after 5:30 p.m. then the dose should be incrementally reduced in size until it is eliminated (*e.g.,* by 9:00 p.m.). Substitute doses may be inserted during the light therapy phase of treatment or by increasing other existing doses increased to compensate for any missed treatment.
T4. Optimal Frequency and Time of Dosing	Three doses of DA replacement therapy per day: Example times of 8:00 a.m., 1:30 p.m., and 5:30 p.m.. Existing times of drug administration can be moved by half hour increments to achieve a balance between optimal therapeutic effects and minimal side effects and to approximate the optimal dosing regimen.
T5. Ceiling dose	Patients on doses larger than 600 mg of DA replacement therapy per day in three equally divided lots can incrementally reduce their total dose of DA replacement therapy by ¼ to ½ dose increments while balancing therapeutic effects and adverse effects.
T6. Time of Phototherapy	Exposure to light should commence between the hours of 7:00 p.m. and 10:00 p.m. Drug regimens should not be altered until an observation period of 2-4 weeks has been undertaken and the patient is in compliance.
T7. Duration of Phototherapy	The duration of phototherapy should last for 1 hour and should be undertaken daily.
T8. Frequency and Intensity of Emission	The frequency of emission should be polychromatic light with an intensity of about 1,000 lux to about 1,500 lux.

As is apparent from TABLE 8, in addition to therapies that include the administration of drugs in conjunction with light therapy, the present invention

includes methods for reducing the dosages of drugs administered in the treatment of motor-related neurological conditions. Thus, the course of pharmacological treatment for a subject that suffers from a motor-related neurological condition may be revised to decrease the subject's dependence on one more drugs (*e.g.,* a dopamine analog, an analog of another neurotransmitter, etc.).

A reduction in the dosage of drugs administered to a subject that suffers from a motor-related neurological condition is particularly desirable when the subject suffers from side effects of the drugs. As an example, PD patients may experience dyskinaesia, hyperkinaesia or other side effects of DA replacement therapy. These side effects are typically due to overdosing. An example of a procedure for reassessing and treating PD and these side effects with drug and light therapies is described by TABLE 9.

TABLE 9

Rule	**Example Conditions for Photo-Pharmacological Intervention in A Patient Experiencing Hyperkinaesia or Dyskinaesia after Pharmacological Treatment**
D1. Treatment Response Stabilization (TRS)	In patients that have been maintained on DA replacement therapy for at least two years, it is first important that the patient experience some stability in their therapeutic response to their drug regimen prior to commencing added treatment with light therapy. This requires professional assessment and stabilization for a period of time from 4-8 weeks.
D2. First Dose	If a patient experiences a symptom-free period at any time during the day or night, the first task is to identify the time when the PD symptoms first appear. Doses of DA replacement the day should be administered strategically around the time identified.
D3. Last Dose	The last daily dose of DA replacement should not occur any later than 5:30 p.m. A patient should not be woken to take medication. If dosing occurs after 9:00 p.m. then the dose should be incrementally reduced in size until it is eliminated. Substitute doses may be inserted during the light therapy phase of treatment or by increasing other existing doses increased to compensate for any missed treatment.

D4. Optimal Frequency and Time of Dosing	Three doses of DA replacement therapy per day: Example times of 8:00 a.m., 1:30 p.m., and 5:30 p.m. Existing times of drug administration can be moved by half hour increments to achieve a balance between optimal therapeutic effects and minimal side effects and to approximate the optimal dosing regimen. If additional doses are required, they should be inserted at times determined after detailed monitoring of therapeutic effects versus adverse side effects.
D5. Ceiling Dose	Patients on doses larger than 600 mg of DA replacement therapy per day in three equally divided lots can incrementally reduce their total dose of DA replacement therapy by ¼ to ½ dose increments while balancing therapeutic effects and adverse effects.
D6. Time of Phototherapy	Exposure to light should commence between the hours of 7:00 p.m. and 10:00 p.m. Drug regimens should not be altered until an observation period of 2-4 weeks has been undertaken and the patient is in compliance.
D7. Duration of Phototherapy	The duration of phototherapy should last for 1 hour and should be undertaken daily.
D8. Frequency and Intensity of Emission	The frequency of emission should be polychromatic light with an intensity of about 1,000 lux to about 1,500 lux.

TABLE 10 sets forth a protocol that may be followed under circumstances where a patient experiences secondary symptoms and side effects of DA replacement therapy, such as depression, insomnia or anxiety. The protocol set forth by TABLE 10 may also be followed to reduce the consequences of polypharmacy in a patient.

TABLE 10

Rule	**Example Conditions for Photo-Pharmacological Intervention in A Patient Experiencing Secondary Symptoms Such As Insomnia, Depression and Anxiety to Reduce Polypharmacy**
PAD1. Treatment Response Stabilization (TRS)	In patients that have been maintained on DA replacement therapy, are experiencing secondary symptoms such as depression, insomnia or anxiety and are undergoing drug treatment for such conditions, it is important that their conditions and treatments be clearly identified and stable before commencing this program.
PAD2 Withdrawing Anxiolytic, Antidepressant and Soporific Medications	After the administration of phototherapy for at least four weeks, its effects on depression, anxiety and insomnia should be carefully assessed. If these conditions have stabilized or improved, the daily dosage of drugs administered for these conditions can be gradually reduced by ¼ to ½ increments as the antidepressant, anxiolytic or soporific effects of phototherapy take effect. Careful monitoring of affect, sleep and anxiety must be undertaken professionally

PAD3. Time of Phototherapy	In the first instance, exposure to light should commence between the hours of 7:00 p.m. and 10:00 p.m. Drug regimens should not be altered until an observation period of 2-4 weeks has been undertaken and the patient is in compliance.
PAD4. Duration of Phototherapy	The duration of phototherapy should last for 1 hour and should be undertaken daily.
PAD5. Frequency and Intensity of Emission	The frequency of emission should be polychromatic light with an intensity of about 1,000 lux to about 1,500 lux.

When a patient experiences tolerance to drug therapies, a protocol such as that set forth in TABLE 11 may be followed.

TABLE 11

Rule	**Example Conditions for Photo-Pharmacological Intervention in A Patient Experiencing Tolerance to DA Replacement Therapy, Including wearing off, Freezing and Between-Dose Loss of Efficacy**
T1. Treatment Response Stabilization (TRS)	In patients that have been maintained on DA replacement therapy and are experiencing secondary symptoms such as depression, insomnia or anxiety and are undergoing treatment with drugs for such conditions, it is important that their conditions and treatments be clearly identified and stable before commencing this program.
T2 Withdrawing Anxiolytic, Antidepressant and Soporific Medications	After the application of phototherapy for at least four weeks, the effects of phototherapy on depression, anxiety and/or insomnia should be carefully assessed. If these conditions have stabilized or improved, as the antidepressant, anxiolytic or soporific effects of phototherapy take effect, the daily doses of the administered drug can be gradually reduced by ¼ to ½ increments. Careful monitoring of affect, sleep and anxiety must be undertaken professionally.
T3. Time of Phototherapy	In the first instance, exposure to light should commence between the hours of 7:00 p.m. and 10:00 p.m. Drug regimens should not be altered until an observation period of 2-4 weeks has been undertaken and the patient is in compliance.
T4. Duration of Phototherapy	The duration of phototherapy should last for 1 hour and should be undertaken daily.
T6. Frequency and Intensity of Emission	The frequency of emission should be polychromatic light with an intensity of about 1,000 lux to about 1,500 lux.

TABLE 12 provides an example of a process for assessing and treating PD over long periods of several months to years with the purpose of slowing or

preventing the ongoing degenerative process so as to keep the symptoms of a PD patient from worsening.

TABLE 12

Rule	**Conditions for Long-Term Photo-Pharmacological Intervention to Prevent Progression of the Disease Process**
LT1. Treatment Response Stabilization	Patients should be monitored as described above in response to their daily drug regimen for primary motor symptoms and should remain stable with as few changes to their drug regimen as possible for the duration of treatment.
LT2 Conditions of Treatment	Light exposure should occur daily at the time required to achieve optimal therapeutic response. The number of omissions should not exceed one every two weeks, and changes to DA replacement therapy should be avoided. If the patient must be brought back into control by use of drugs, then the dose required to do so should be titrated by ¼ to ½ doses and applied at strategic times, as defined in TABLE 7.
LT3. Time of Phototherapy	Exposure to light should commence between the hours of 7:00 P.M. and 10:00 pm. Drug regimens should not be altered until an observation period of 2-4 weeks has been undertaken and the patient in compliant with phototherapy and titration.

FIGs. 1 through 4 depict the effects of combining melatonin regulation therapies, such as light therapy, with drug therapy to treat motor-related neurological conditions.

In a specific embodiment, when drug and light therapies are combined, 100 mg of L-dopa may be administered to a subject three (3) times daily, with administration of the first dose occurring approximately thirty (30) minutes prior to symptom onset, and the last dose being administered at about 5:30 p.m. When the subject suffers from PD, the subject will typically remain asymptomatic for about the same amount of time every morning after he or she wakes (*e.g.,* about an hour, up to three (3) hours, etc.). Thus, the subject will know when symptoms will start to occur during the day and, therefore, will know when to take the first dose of L-dopa.

Depending upon the severity of symptoms experienced by a particular subject, higher dosages of L-dopa may be required. FIG. 21 depicts the standard dosages of L-dopa (and a variety of other dopamine derivatives) that are prescribed for subjects who suffer from varying degrees of Parkinson's Disease. Nevertheless, when drug

and light therapy are used together in accordance with teachings of the present invention, below-standard L-dopa dosages may be administered to a subject.

Of course, the same rationale may be applied to other dopamine derivative therapies by substituting an equivalent dosage of the other dopamine derivative for 100 mg of L-dopa (*see, e.g.,* FIG. 21, which depicts equivalent dosages for a variety of dopamine derivatives). Similar drug dosages may also be applied to other motor-related neurological conditions.

In the graph of FIG. 1, the effects of light therapy alone and with drug treatment on a newly diagnosed, or *de novo,* Parkinson's disease patient are illustrated. On the left side of the graph, the tremors experienced by the patient were evaluated. Specifically, a visual analog scale was used to quantify the patient's tremors. The tremors initially experienced by the patient (labeled "March 18") are compared with the tremors experienced by the patient after eight (8) weeks of light therapy alone (daily ocular exposure to bright white light at an intensity of about 1,000 lux to about 1,500 lux) (labeled "May 12") and the tremors experienced by the patient after another eight (8) weeks of light therapy in conjunction with drug therapy (labeled "June 9"). With light therapy alone, the patient's tremors decreased by about 20%. When light therapy was used in conjunction with drug therapy, the subject's tremors decreased by 56%.

On the right side of the graph of FIG. 1, micrographia, or a progressive decrease in the patient's handwriting, which is symptomatic of motor-related neurological conditions, such as PD, was evaluated. The diagonal distance across a routine sample of signature was measured. During the initial test, the diagonal measure of the patient's handwriting measured 16 mm. After eight (8) weeks of light therapy, the size of the patient's handwriting measured 19 mm. Eight (8) weeks after the addition of drug therapy, the diagonal measure of the patient's handwriting exhibited a further increase—to 25 mm.

The decreases in tremors and micrographia (*i.e.,* the increase in handwriting size) demonstrate the therapeutic value of using light therapy alone or in combination with pharmacological treatment. The following results specifically illustrates that a long-term regimen of light therapy and drug treatment in accordance with teachings of the present invention can have a disease-modifying effect on (*e.g.,* slow or halt the progression of, etc.) a degenerative neurological disease.

FIG. 2a shows the effects of light therapy on a patient who had been receiving dopamine replacement therapy (*i.e.*, drugs) for several years. The indicators of the effectiveness of light therapy included a "latency to walk" exercise, in which the time it took the patient to walk a distance of three meters then return was measured; a "fist to elbow latency" analysis was conducted, in which the time it took the patient to repeatedly move his or her hand from the first to the elbow of the patient's other, vertically oriented arm (FIG. 5) ten times was measured; and a "floor to knee latency" analysis was conducted, in which the time it took the patent to raise his or her foot from the floor to knee level (FIG. 6) ten times was measured. The results of the latency to walk tests are depicted as squares (■) in the graph of FIG. 2a. The results of the fist to elbow latency tests appear as triangles (▲) in the graph of FIG. 2a. The results of the floor to knee latency analyses are depicted as circles (●) in the graph of FIG. 2a.

All three tests were conducted at three distinct times: (1) a pre-assessment before the initiation of light therapy; (2) a second session after the patient received daily light therapy for about seven (7) weeks; (3) a third session after the patient received daily light therapy for an additional eleven (11) weeks; and (4) a fourth session about twenty (20) weeks later, during which light therapy treatments were occasionally skipped. All three of the measures that had been evaluated exhibited improvement over the course of treatment, including striking initial rates of improvement and overall improvements of 21%, 25%, and 33% for the latency to walk, fist to elbow latency, and floor to knee latency, respectively, measured in decreases in the time it took the patient to perform the prescribed exercises.

FIG. 2b demonstrates the improvements achieved in a patient's ability to complete the floor to knee latency exercise over the course of a regimen of light therapy administered in conjunction with previously prescribed DA replacement therapy. Again, a measured improvement of about 30%, measured in terms of a decrease in the time it took the patient to complete the exercise, was observed.

The chart of FIG. 3 shows the results of light therapy on a subject who had been receiving DA replacement therapy for a prolonged period of time, but continued to experience severe involuntary movements (dyskinesia). After about six months of light therapy, in addition to continued DA replacement therapy, the patient's dyskinesia diminished by about 80%.

In the graph of FIG. 4, the effects of light therapy, in conjunction with continued drug (DA replacement) therapy, on various secondary symptoms of motor-related neurological conditions or side effects of DA replacement therapy. Specifically, the effects of light therapy (with continued drug therapy) on insomnia (♦), nocturnal movement (▲), depression (■), and anxiety (●) are shown. Specifically, the graph of FIG. 4 shows that the addition of light therapy to a regimen of pharmacological treatment decreased anxiety by 58%, insomnia by 66%, nocturnal movement by 95%, and depression by 100%.

In addition to the individualized results depicted by FIGs. 1-4, a larger-scale study was conducted. In that study, polychromatic light therapy was administered to subjects who were receiving drug treatment for motor-related neurological conditions. Specifically, light therapy, in the form of polychromatic light having peaks at about 435nm to about 436 nm, about 460 nm to about 520 nm, about 540 nm to about 560 nm, and about 640 nm was administered at an intensity of about 1,000 lux to about 1,500 lux. The irradiance of the blue-green light present in the light administered to each subject was about 280 $\mu W/cm^2$, while the irradiance of the red light present in that light was only about 150 $\mu W/cm^2$.

The study, which had a duration of forty-three (43) months, involved 94 subjects. The subjects were divided into two groups: (A) thirty-one (31) Parkinson's disease patients who received standard drug therapy, but not light therapy; and (B) sixty-three (63) Parkinson's disease patients who received light therapy in addition to drug therapy, in the manner set forth in TABLE 8.

A variety of factors, including primary symptoms of Parkinson's disease and other motor-related neurological conditions (*e.g.,* balance (FIG. 7), bradykinaesia (FIG. 8), fist to elbow latency (FIG. 9), latency to walk (FIG. 10) and tremor (FIG. 11), rigidity (FIG. 12), nocturnal movement and dyskinesia (FIG. 13), etc.) and secondary symptoms of Parkinson's disease and other motor-related neurological conditions (*e.g.,* anxiety (FIG. 14), insomnia (FIG. 15), etc.) were evaluated at the outset of the study, and at periodic intervals throughout the study. As illustrated by FIGs. 7-15, when only drug treatment was provided, all of these symptoms but latency to walk (FIG. 10) either remained the same or worsened over time. When light therapy was added to drug therapy, a significant decrease in the severity of all of the

symptoms was realized (latency to walk—FIG. 10—improved at about the same rate in both groups of subjects).

In another study, the effects of yellow-green light on subjects who suffered from Parkinson's disease were evaluated. In that study, which was conducted on seven (7) subjects over an eight (8) month period of time, light therapy was administered by positioning a yellow-green filter over the light source. The narrow band isolated intensity of the yellow-green light at each subject's eyes was about 880 lux, and included an above-ambient amount (an irradiance of about 130 $\mu W/cm^2$) of blue-green light and a below-ambient amount (an irradiance of about 40 $\mu W/cm^2$) of red light. As shown in FIGs. 16 and 17, the administration of green light therapy resulted in gradual, consistent improvements in the primary symptoms of Parkinson's disease and many other motor-related neurological conditions, as evaluated by fist to elbow latency, knee to floor latency and latency to walk tests (FIG. 16), and evaluation of each subject's arm swing, the severity of each subject's tremors and nocturnal movement by each subject (FIG. 17). Secondary symptoms of motor-related neurological conditions were also improved, as represented by the evaluation of anxiety shown in FIG. 17.

Turning now to FIG. 18, long-term light therapy has an effect on the drug dosages that are needed to address the symptoms of subjects who suffer from motor-related neurological conditions. FIG. 18 is a graph that depicts the drug dose requirements of various groups of subjects at the beginning ("Before") and end ("After") of the forty-three (43) month study.

The first (left-most) pair of bars on graph represents the drug dosages required by Parkinson's disease patients who did not receive light therapy. At the outset of the study, these subjects received, on average, 833 mg of L-dopa each day. After forty-three (43) months, the average drug dosage per-subject increased to 1142 of L-dopa each day. This represents a drug burden increase of about thirty-seven percent (37%) over forty-three (43) months. As shown in FIGs. 7-15, although drug dosages were increased over time, the symptoms of the motor-related neurological conditions suffered by these subjects actually worsened with time.

The second pair of bars represents the drug dosages administered to subjects who also received long-term periodic light therapy for their motor-related neurological conditions. On average, drug dosages were substantially constant

(*e.g.*, an increase of only about two percent (2%), etc.) over the forty-three (43) month study, with the initial average daily L-dopa dosage being about 969 mg and the final average daily L-dopa dosage being about 990 mg. Over that time, as shown in FIGs. 7-15, most of the symptoms of the motor-related neurological conditions suffered by the subjects who received light therapy improved (*i.e.*, decreased in severity) significantly, even without any substantial increase in drug dosage.

As illustrated by the third, fourth and fifth pairs of bars in the graph of FIG. 18, the need for higher drug dosages over time decreased as the subject's compliance with prescribed light therapy regimens increased. As indicated by the fourth pair of bars, subjects who were "semi-compliant" (*i.e.*, subjects who occasionally skipped a light therapy session or cut light therapy sessions short) initially required an average of 1056 mg of L-dopa each day and, at the end of the study, required an average of 1094 mg of L-dopa each day (a dosage increase of about three and a half percent (3½%)). Subjects who were more compliant (*i.e.*, subjects who skipped or cut short a light therapy session less than once a week)—shown as the third pair of bars—initially required, on average, 910 mg of L-dopa per day and by the end of the study required, on average, 926 mg of L-dopa per day (a dosage increase of less than two percent (2%)). Subjects who rarely, if ever (*i.e.*, less than once a month), skipped or cut short a light therapy session required, on average, only three (3) more milligrams of L-dopa at the end of the study (591 mg/day) than they did at the beginning of the study (588 mg/day) (about a half a percent (½%) increase).

The data provided in FIG. 18 indicate that, when light therapy is provided on a substantially regular basis to a subject who suffers from a motor-related neurological condition, the dosages of drugs administered to the subject may remain substantially the same over prolonged periods of time (*e.g.*, a year or more, three years, four years, five years, etc.). In addition, when considered in conjunction with FIGs. 7-15, the data of FIG. 18, suggest that a combination of drug therapy and light therapy in accordance with teachings of the present invention may enable a reduction in drug dosages while preventing any increases (and, in some cases, actually decreasing) the severity of symptoms experience by a subject who suffers from a motor-related neurological condition.

These results demonstrate that the addition of light therapy in accordance with teachings of the present invention to the overall treatment regimen for subjects who

are long-term sufferers of at least one motor-related neurological condition may abate symptoms of the motor-related neurological condition. This improvement in a subject's quality of life may be maintained by continuing to provide the subject with light therapy and drug therapy, with the added possibility of reduced drug dosages or reducing the rate at which drug dosages are increased over time. Combining strategic light therapy with drug therapy may also stop the progression of motor-related neurological conditions.

In addition to methods for addressing motor-related neurological conditions, the present invention includes techniques for diagnosing motor-related neurological conditions. Such a technique may include exposing a subject to certain wavelengths of light (*e.g.,* amber, orange, red, etc.) without exposing the subject to other wavelengths of light (*e.g.,* blue, blue-green, green, etc.). These wavelengths may temporarily inhibit dopaminergic activity. For example, melatonin production or melatonergic activity by a subject may be temporarily increased. A temporary increase in melatonergic activity may temporarily exacerbate the symptoms of a motor-related neurological condition, which may facilitate a physician's diagnosis of the motor-related neurological condition. This same phenomenon may be elicited, in some embodiments, by administering increased levels or isolated levels of amber, orange and/or red light (*e.g.,* about the same or greater levels of amber, orange and/or red light than is present in ambient indoor light, at a greater collective intensity than blue, blue-green and/or green light, with wavelengths from 570 nm to 750 nm having a greater collective intensity than the collective intensity of wavelengths from 460 nm to 570 nm, etc.) to the subject.

In some embodiments, certain wavelengths of light may be filtered or otherwise removed from the light that is administered to a subject who is predisposed to or who may be suffering from a motor-related neurological condition. Without limiting the scope of the present invention, wavelengths of 570 nm or less may be removed from the diagnostic light. These wavelengths may include green and/or blue-green wavelengths of light. In other embodiments, levels of administered light having wavelengths above 570 nm or levels of light having wavelengths of above 570 nm to 750 nm may exceed levels of administered light with wavelengths of 570 nm or less. In some embodiments, the subject may be exposed to one or more isolated bandwidths of amber, orange and/or red light.

In the event that physician determines that the subject is likely to suffer from a motor-related neurological condition or suffers from a motor-related neurological condition, the physician may prescribe a course of treatment for the diagnosed condition. A prescribed course of treatment may include, among other things, stimulating a dopaminergic response by the subject's body, which may adjust levels of one or more monoamines within the subject's body (*e.g.*, one or more of the subject's melatonin, serotonin and/or dopamine levels, etc.). This may be done in any suitable manner, for example, with ocular light therapy alone or in connection with the administration of one or more drugs, and/or other suitable treatments.

One specific embodiment of a process for expediting the diagnosis of a motor-related neurological condition, such as PD, is described in TABLE 13.

TABLE 13

Rule	**Conditions for Early Diagnosis and Developing A Rationale for Early Treatment Thereby Preventing the Onset and Worsening of PD**
ED1. Treatment Response Stabilization	PD Patients and undiagnosed patients should be monitored as described above in response to their daily drug regimen for primary motor symptoms and should remain stable with as few changes to their drug regimen as possible for the duration of treatment or observation
ED2 Conditions of Treatment	Exposure to red light should occur daily at the same time each day, usually in the evening. The number of omissions should not exceed one day every two weeks. Changes to DA replacement therapies and other medications should be avoided.
ED3. Time of Phototherapy	Exposure to light should commence between the hours of 7:00 p.m. and 10:00 p.m. Drug regimens should not be altered until an observation period of 2-4 weeks has been undertaken and the patient is in compliance with phototherapy and titration. The condition and well-being of the patient is monitored twice weekly during the course of treatment and terminated as soon as symptoms are manifest.

FIG. 19 is a chart that shows the relative effects of polychromatic light and red light on the following Parkinson's disease symptoms: Agitation, anxiety, features on challenge, bradykinesia, depression, dreaming, dyskinesia, irritability, mood swing, rigidity, sleep and tremor will be exacerbated.

As shown in the left side of the chart, treatment with polychromatic light (daily treatment for one hour at an intensity of about 1,000 lux to about 1,500 lux)

improved an average of sixteen (16) known PD symptoms in the treated patients, while treatment with red light yielded, on average, no improvement in PD symptoms in the treated subjects. Rather, as illustrated by the right side of the chart of FIG. 19, exposure to red light exacerbated about eleven (11) symptoms in the treated subjects, while polychromatic light only exacerbated an average of two known PD symptoms in the treated patients.

From these results, the utility of using red light (or amber and/or orange light) to enable early detection of motor-related neurological conditions is apparent. In addition, it can be seen that the red portion of polychromatic light may have detrimental effects on patients who suffer from motor-related neurological conditions.

In a specific embodiment, a subject who is believed to be prone to a motor-related neurological condition or who may be suffering from the early stages of a motor-related neurological condition may be subjected to diagnostic therapy. Such diagnostic therapy may be affected by exposing the subject to one or more of red, orange and/or amber light. The light may be administered to the eyes of the subject. In some embodiments, repeated (*e.g.,* daily, three times a week, etc.) administrations for prolonged periods of time (*e.g.,* one week, two weeks, one month, etc.) may be useful in providing an accurate diagnosis.

FIG. 20 illustrates the effects of light therapy along with drug therapy to treat Parkinson's disease. A long-term coefficient ($LT_{coeff.}$) was calculated using the following formula:

$$LT_{coeff.} = (n_{SI}(+1) + n_{SD}(-1) + n_{SNC}(0))/\ n_{SI} + n_{SD} + n_{SNC},$$

where n_{SI} is the number of symptoms showing improvement, n_{SD} is the number of symptoms showing deterioration, and n_{SNC} is the number of symptoms showing no change. The long-term coefficient may enable a subject to better recognize his or her progression as treatment in accordance with teachings of the present invention continues over time, particularly for symptoms where improvements are very gradual, and possibly imperceptible on a day-to-day basis. In some embodiments, the long-term coefficient or any other means for quantifying a subject's progress may be embodied by a computerized feedback system.

Although the foregoing description contains many specifics, these should not be construed as limiting the scope of the invention or of any of the appended claims,

but merely as providing information pertinent to some specific embodiments that may fall within the scopes of the invention and the appended claims. Features from different embodiments may be employed in combination. In addition, other embodiments of the invention may also be devised which lie within the scopes of the invention and the appended claims. The scope of the invention is, therefore, indicated and limited only by the appended claims and their legal equivalents. All additions, deletions and modifications to the invention, as disclosed herein, that fall within the meaning and scopes of the claims are to be embraced by the claims.

CLAIMS

What is claimed:

1. A system for treating a motor-related neurological condition or at least one symptom of the motor-related neurological condition, comprising:

a prescription for administering ocular light therapy to a subject to address the motor-related neurological condition or the at least one symptom of the motor-related neurological condition, the ocular light therapy including simultaneously administered therapeutic peaks, including a first peak of light in a range of 460 nm to about 520 nm having an above average ambient irradiance and a second peak of light in a range of above 520 nm to less than 540 nm having an above average ambient irradiance, with a collective irradiance of light in a range from above 570 nm to 750 nm being below average ambient for the range from above 570 nm to 750 nm; and

means for administering the ocular light therapy.

2. The system of claim 1, wherein the prescription comprises a prescription for ocular light therapy in which each peak in a range from 570 nm to 750 nm has a below average ambient irradiance.

3. The system of claim 1, wherein the prescription comprises a prescription for administering the ocular light therapy at at least one time of day, daily, and for at least one duration.

4. The system of claim 3, wherein the prescription comprises a prescription for administering the ocular light therapy once each day and a prescription for administering a drug for treating the motor-related neurological condition a plurality of times each day.

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5. The system of claim 3, wherein the prescription comprises a prescription for administering ocular light therapy with a same spectral makeup for a plurality of times throughout each day.

6. The system of claim 3, wherein the prescription comprises a prescription for a plurality of time dependent spectral makeups of the ocular light therapy, with one time dependent spectral makeup of the plurality of time dependent spectral makeups corresponding to at least one particular time during the day.

7. The system of claim 1, wherein the prescription comprises a prescription for ocular light therapy capable of stimulating a dopaminergic response.

8. The system of claim 1, wherein the prescription comprises a prescription for ocularly administering the ocular light therapy.

9. The system of claim 1, wherein the means for administering includes means for ocularly exposing the subject to an isolated bandwidth of at least one of amber, orange and red light.

10. The system of claim 9, wherein the means for ocularly exposing the subject to at least one of amber, orange and red light is capable of enhancing at least one symptom of at least one motor-related neurological condition.

11. The system of claim 9, wherein the means for ocularly exposing the subject to at least one of amber, orange and red light comprises means for administering at least one wavelength of light within a range of greater than 570 nm to 750 nm to the subject.

12. The system of any one of claims 1 to 11, further comprising:
a prescription for a drug therapy for the subject, the drug therapy including a dosage of medication for treating the motor-related neurological condition.

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13. The system of claim 12, further comprising:

a replacement prescription for a drug therapy after repeated administration of the ocular light therapy, the replacement prescription prescribing a reduced dose of the medication for administering to the subject.

14. The system of claim 12, wherein the prescription for the ocular light therapy and the prescription for the drug therapy comprise coordinated prescriptions for the light and drug therapies in accordance with an optimal dosing schedule.

15. The system of claim 14, wherein the coordinated prescriptions for the light and drug therapies in accordance with the optimal dosing schedule comprise coordinated prescriptions for administering the ocular light therapy at a different time of the day than administering the drug therapy.

16. The system of claim 14, wherein the prescription for the drug therapy of the coordinated prescriptions for the light and drug therapies in accordance with the optimal dosing schedule comprises a prescription for terminating administration of the drug therapy at a predetermined time of day.

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17. A system for treating a motor-related neurological condition experienced by a subject or at least one symptom of the motor-related neurological condition experienced by the subject, comprising:

a medication that, upon being administered to the subject, treats the motor-related neurological condition experienced by the subject or at least one symptom of the motor-related neurological condition experienced by the subject; and

a light therapy device that delivers light to eyes of the subject with a first therapeutic peak in a range from 460 nm to about 520 nm having an above average ambient irradiance, a second therapeutic peak in a range from above 520 nm to less than 540 nm with an above average ambient irradiance, and with any light in a range from above 570 nm to 750 nm having a collective irradiance that is below average ambient for the range from above 570 nm to 750 nm, the light therapy device capable of simultaneously administering the first therapeutic peak and the second therapeutic peak.

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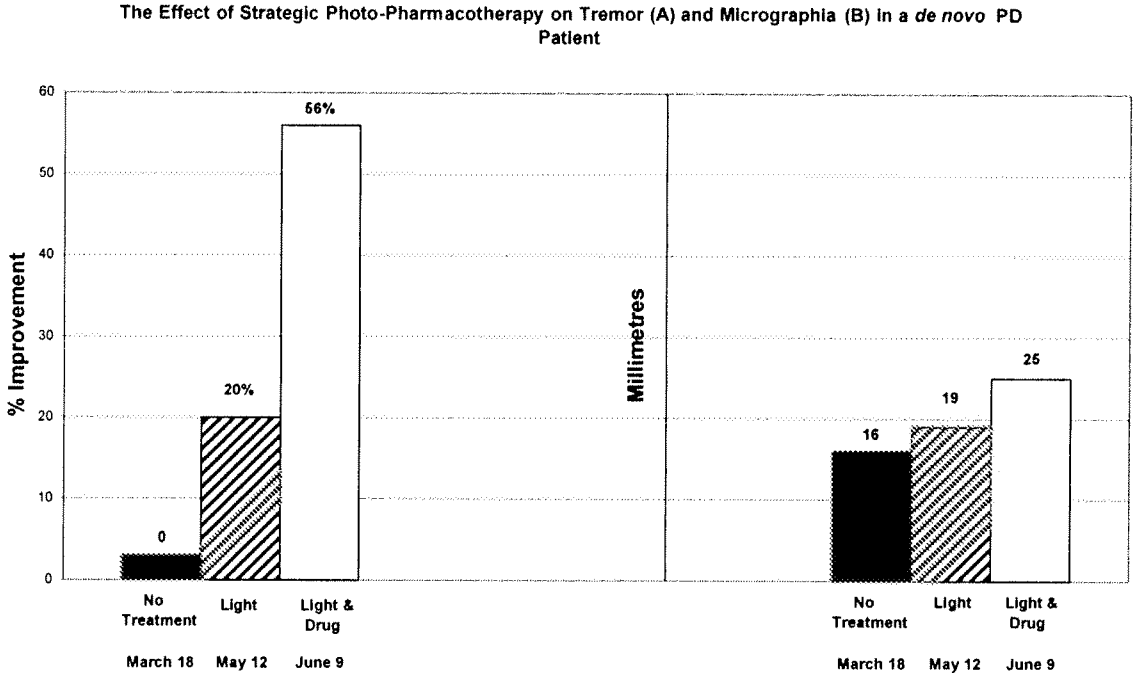
The Effect of Strategic Photo-Pharmacotherapy on Tremor (A) and Micrographia (B) in a de novo PD Patient
% Improvement
60
50
40
30
20
10
0
0
20%
56%
No Treatment
Light
Light & Drug
March 18
May 12
June 9
Millimetres
16
19
25
No Treatment
Light
Light & Drug
March 18
May 12
June 9

Fig. 1

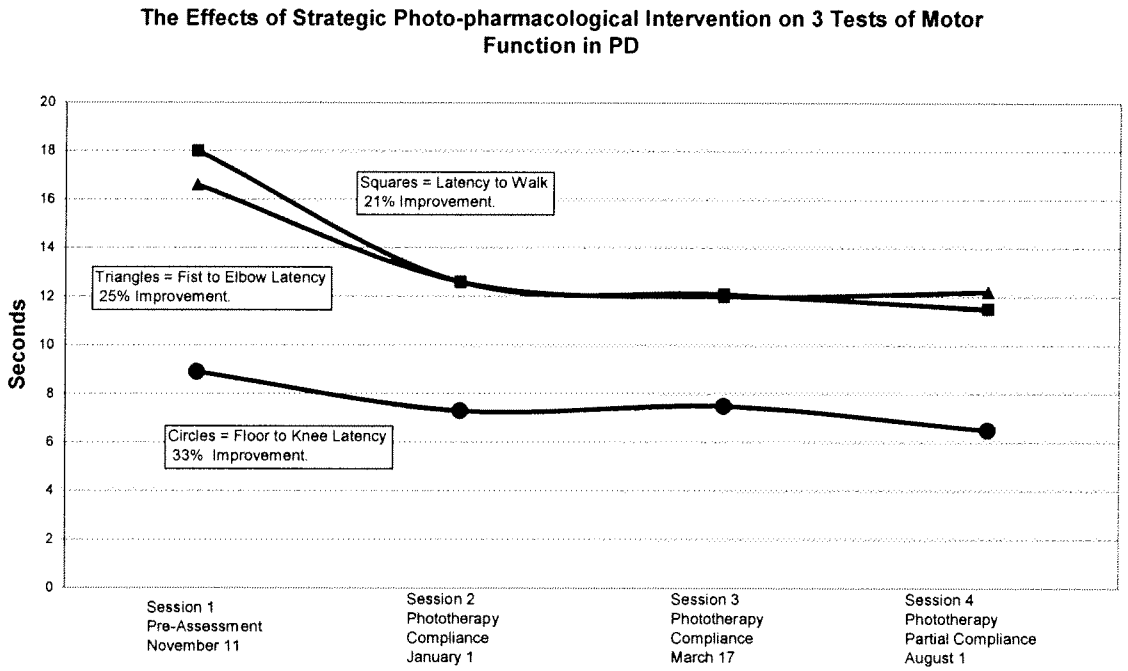
The Effects of Strategic Photo-pharmacological Intervention on 3 Tests of Motor Function in PD
Seconds
20
18
16
14
12
10
8
6
4
2
0
Squares = Latency to Walk
21% Improvement.
Triangles = Fist to Elbow Latency
25% Improvement.
Circles = Floor to Knee Latency
33% Improvement.
Session 1
Pre-Assessment
November 11
Session 2
Phototherapy
Compliance
January 1
Session 3
Phototherapy
Compliance
March 17
Session 4
Phototherapy
Partial Compliance
August 1

Fig. 2a

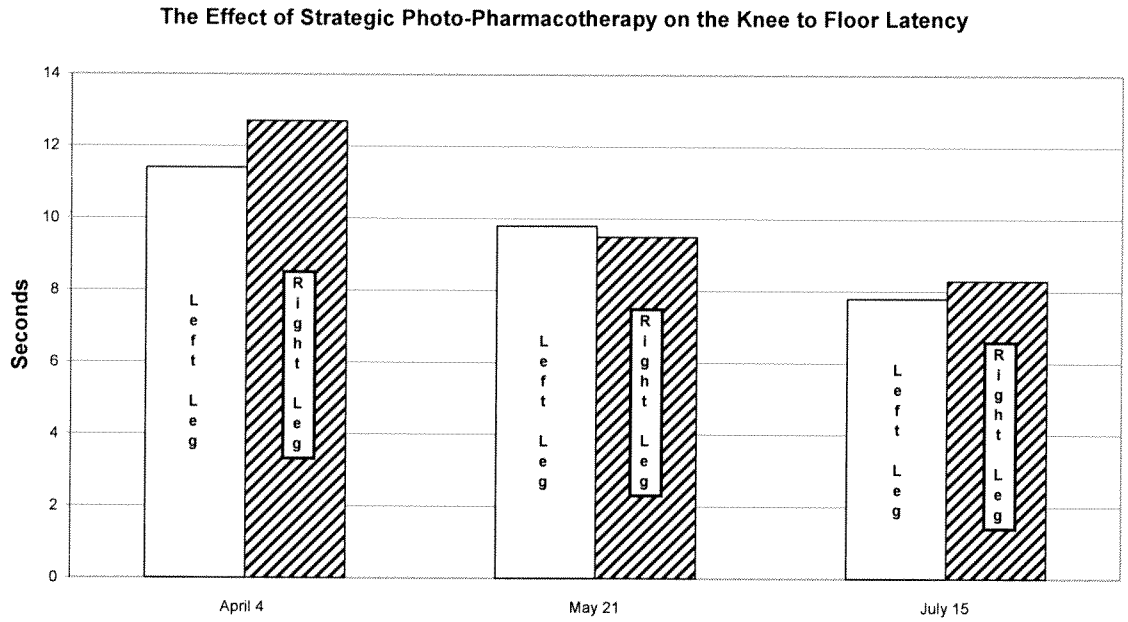
The Effect of Strategic Photo-Pharmacotherapy on the Knee to Floor Latency
Seconds
14
12
10
8
6
4
2
0
Left Leg
Right Leg
Left Leg
Right Leg
Left Leg
Right Leg
April 4
May 21
July 15

Fig. 2b

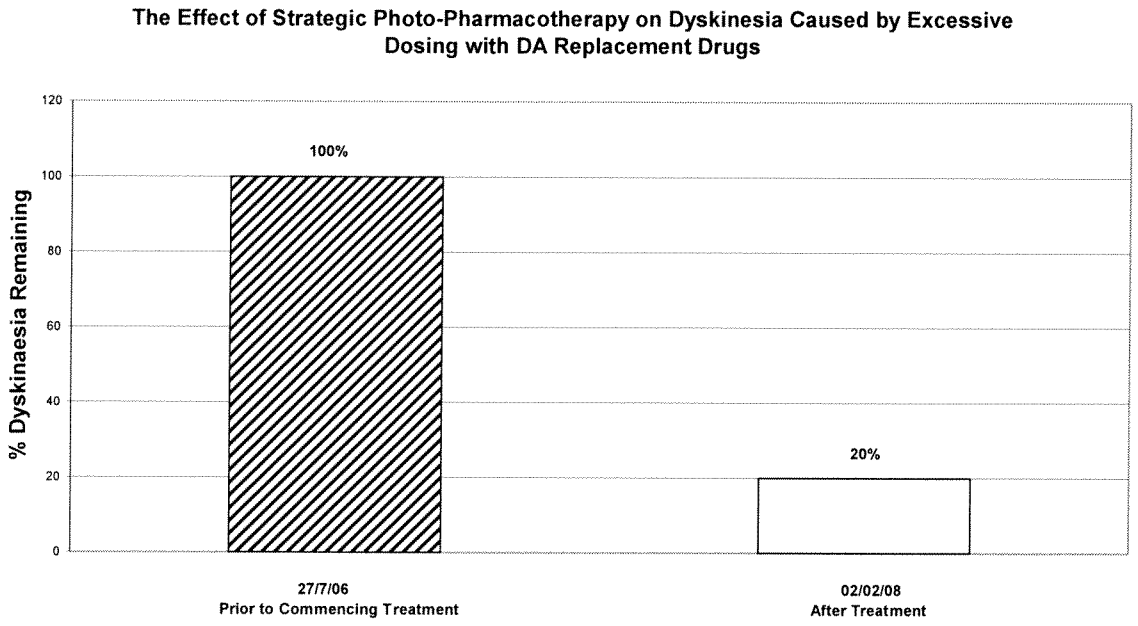
The Effect of Strategic Photo-Pharmacotherapy on Dyskinesia Caused by Excessive Dosing with DA Replacement Drugs
% Dyskinaesia Remaining
120
100
80
60
40
20
0
100%
20%
27/7/06
Prior to Commencing Treatment
02/02/08
After Treatment

Fig. 3

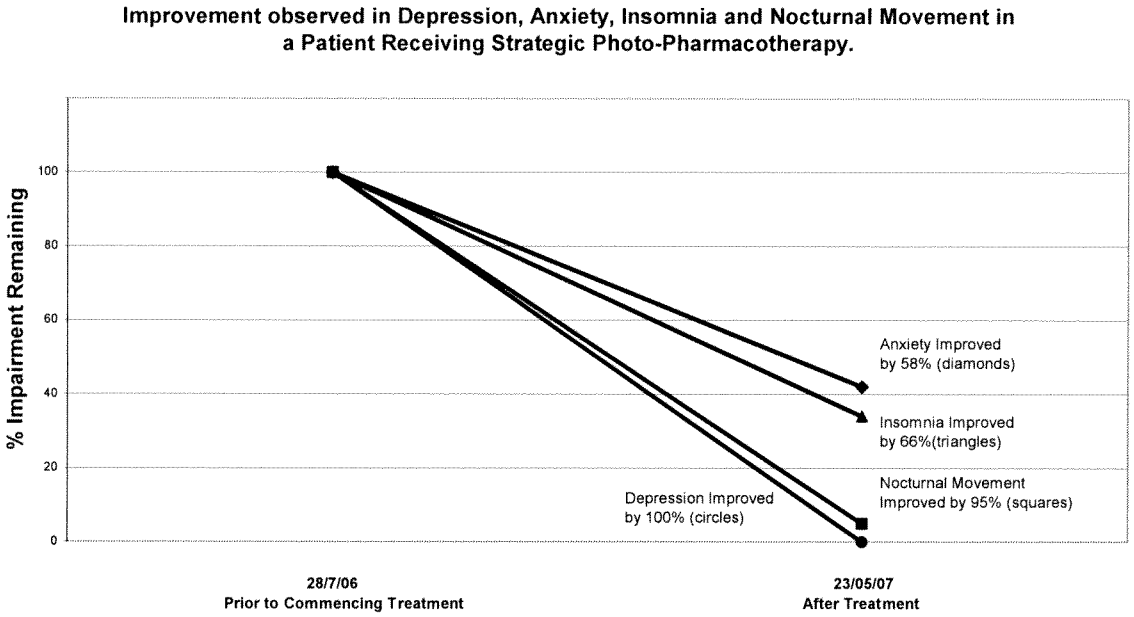
Improvement observed in Depression, Anxiety, Insomnia and Nocturnal Movement in a Patient Receiving Strategic Photo-Pharmacotherapy.
% Impairment Remaining
100
80
60
40
20
0
Anxiety Improved by 58% (diamonds)
Insomnia Improved by 66%(triangles)
Nocturnal Movement Improved by 95% (squares)
Depression Improved by 100% (circles)
28/7/06
Prior to Commencing Treatment
23/05/07
After Treatment

Fig. 4

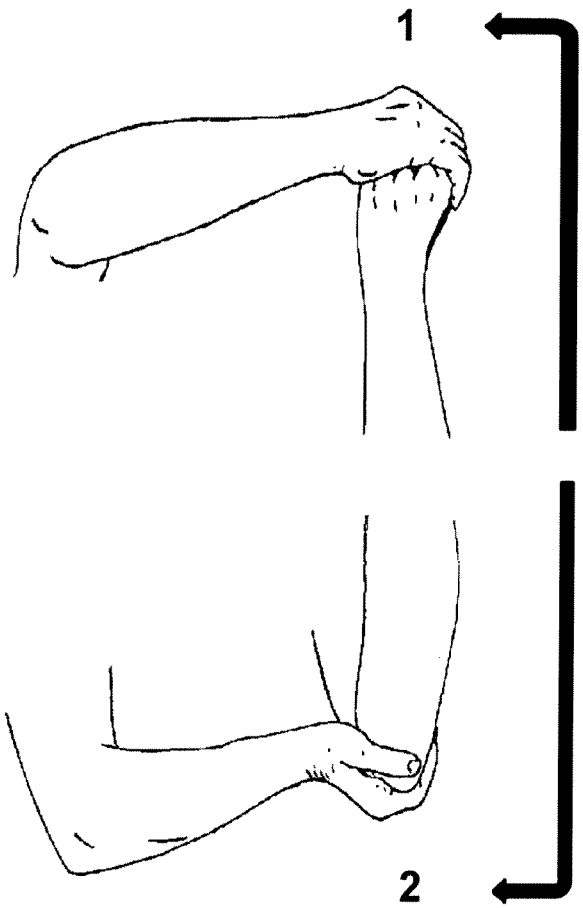

Fig. 5

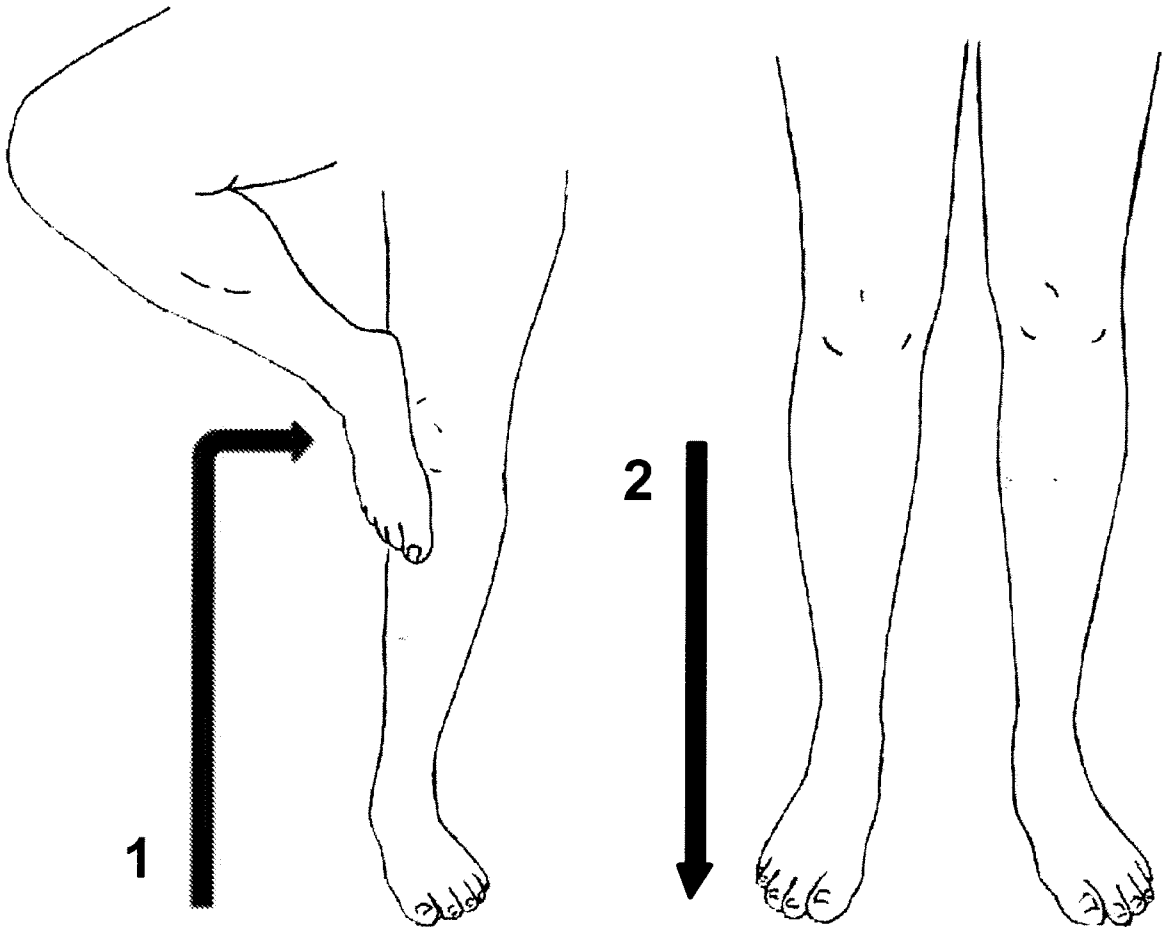

Fig. 6

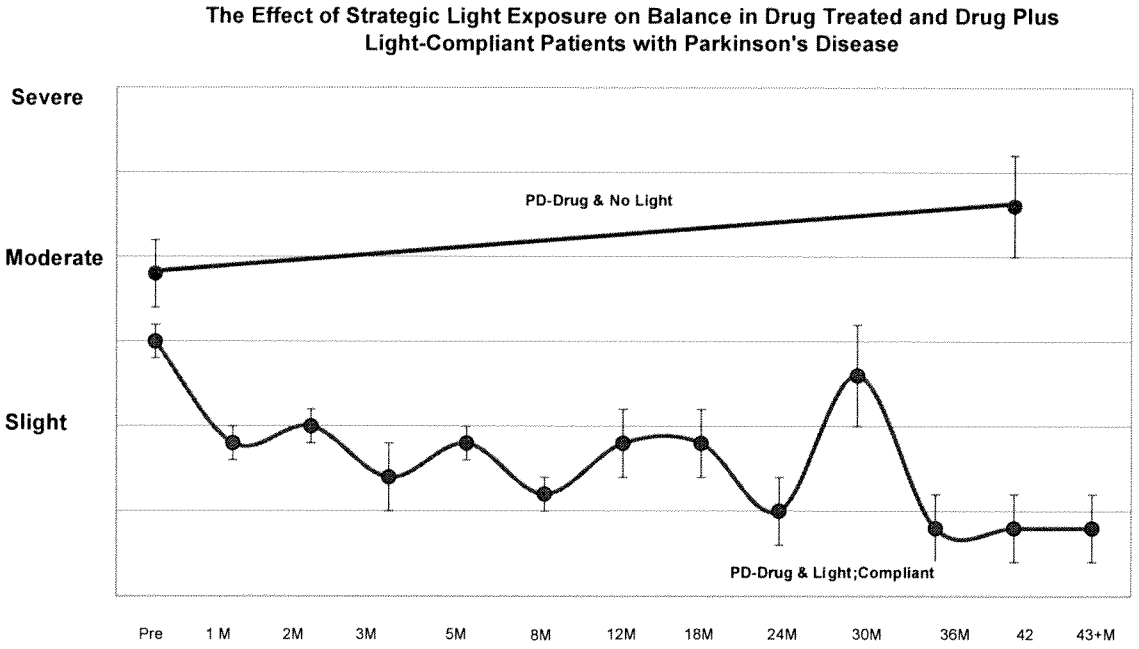
The Effect of Strategic Light Exposure on Balance in Drug Treated and Drug Plus Light-Compliant Patients with Parkinson's Disease
Severe
Moderate
Slight
PD-Drug & No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 7

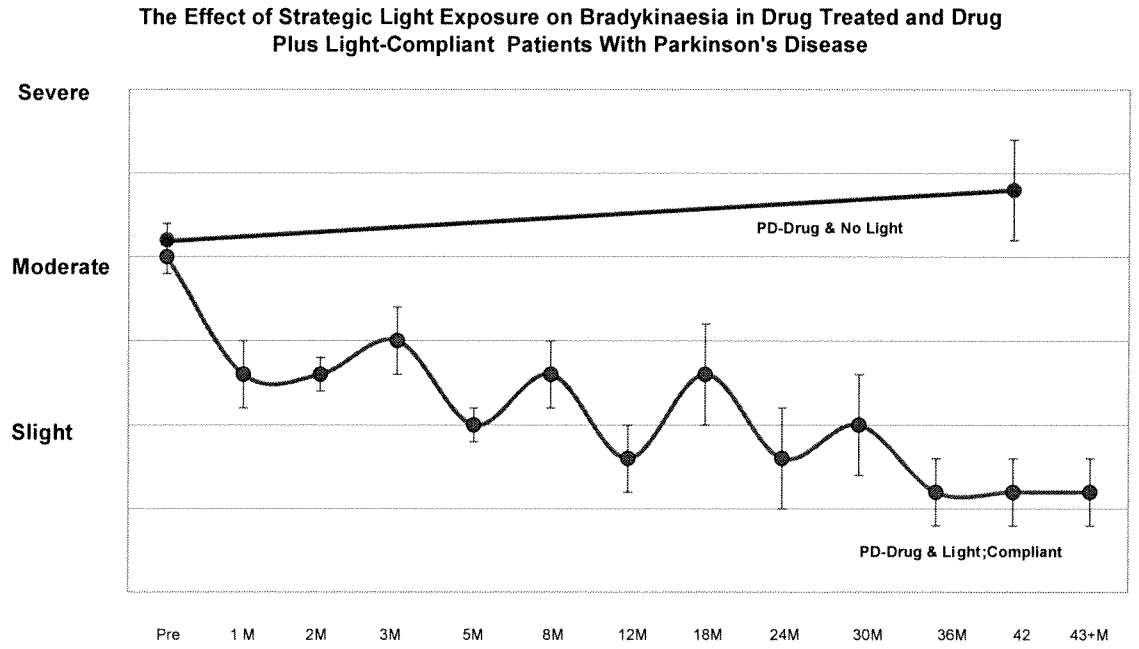
The Effect of Strategic Light Exposure on Bradykinaesia in Drug Treated and Drug Plus Light-Compliant Patients With Parkinson's Disease
Severe
Moderate
Slight
PD-Drug & No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 8

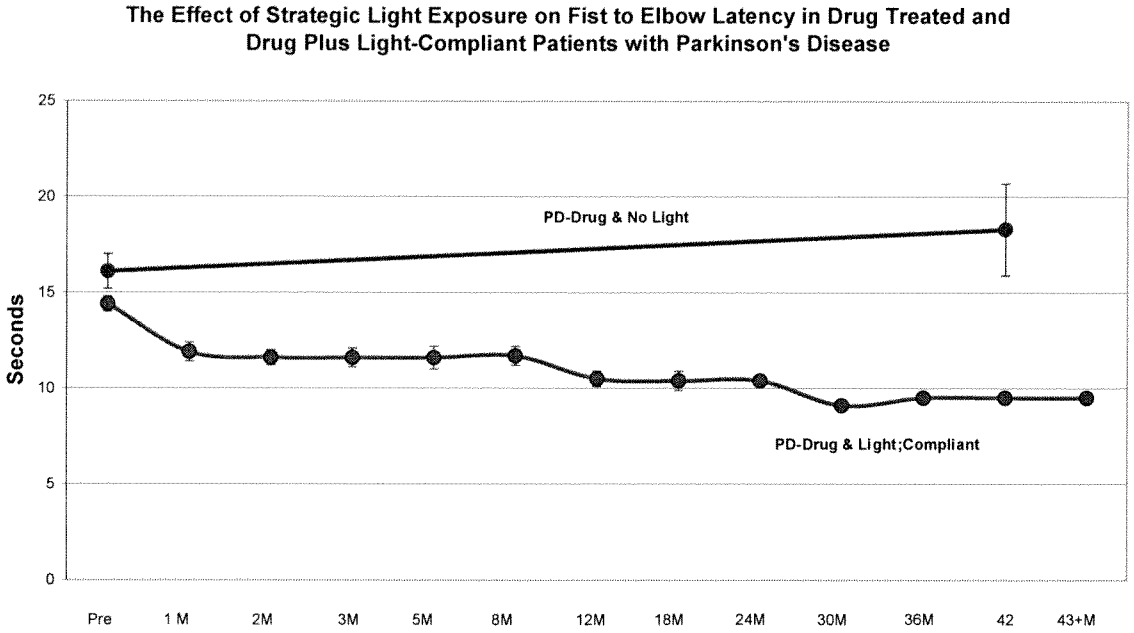
The Effect of Strategic Light Exposure on Fist to Elbow Latency in Drug Treated and Drug Plus Light-Compliant Patients with Parkinson's Disease
Seconds
25
20
15
10
5
0
PD-Drug & No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 9

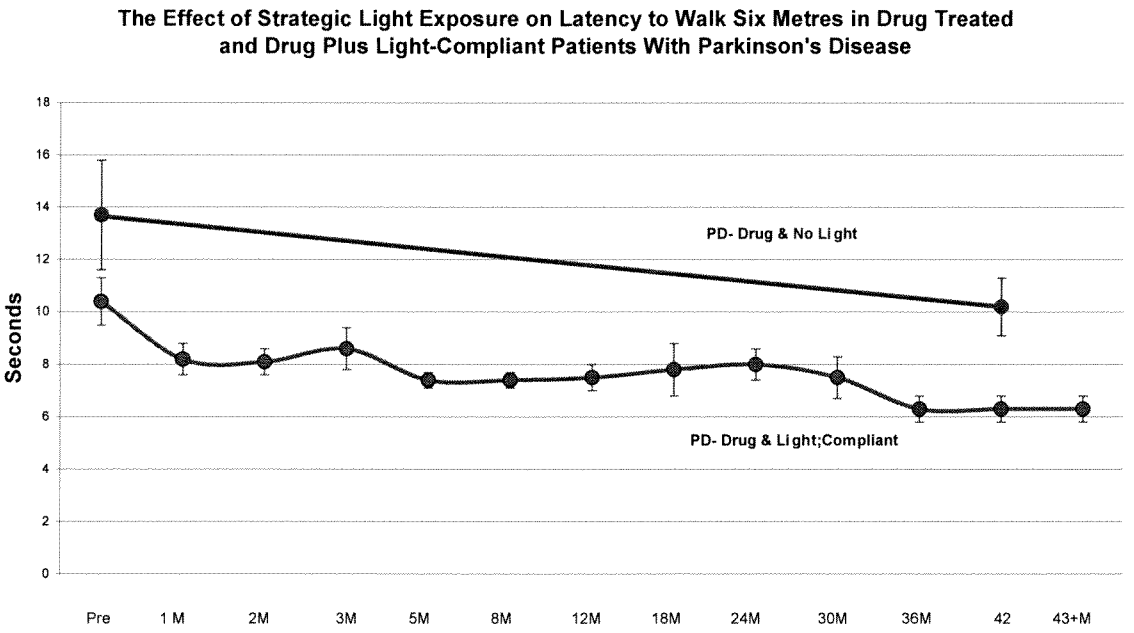
The Effect of Strategic Light Exposure on Latency to Walk Six Metres in Drug Treated and Drug Plus Light-Compliant Patients With Parkinson's Disease
Seconds
18
16
14
12
10
8
6
4
2
0
PD- Drug & No Light
PD- Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 10

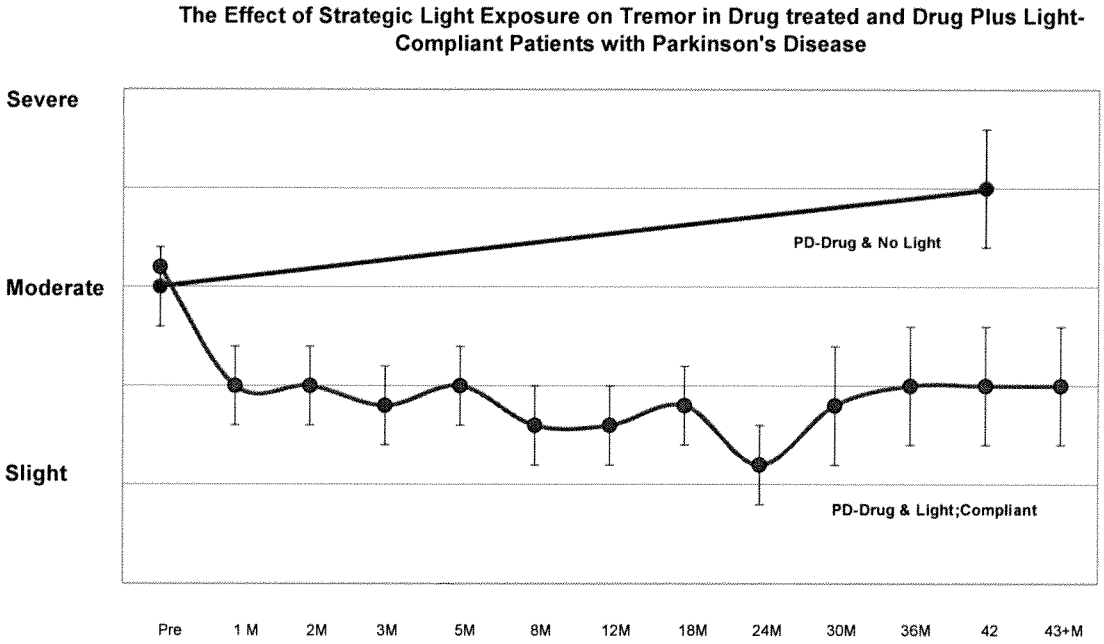
The Effect of Strategic Light Exposure on Tremor in Drug treated and Drug Plus Light-Compliant Patients with Parkinson's Disease
Severe
Moderate
Slight
PD-Drug & No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 11

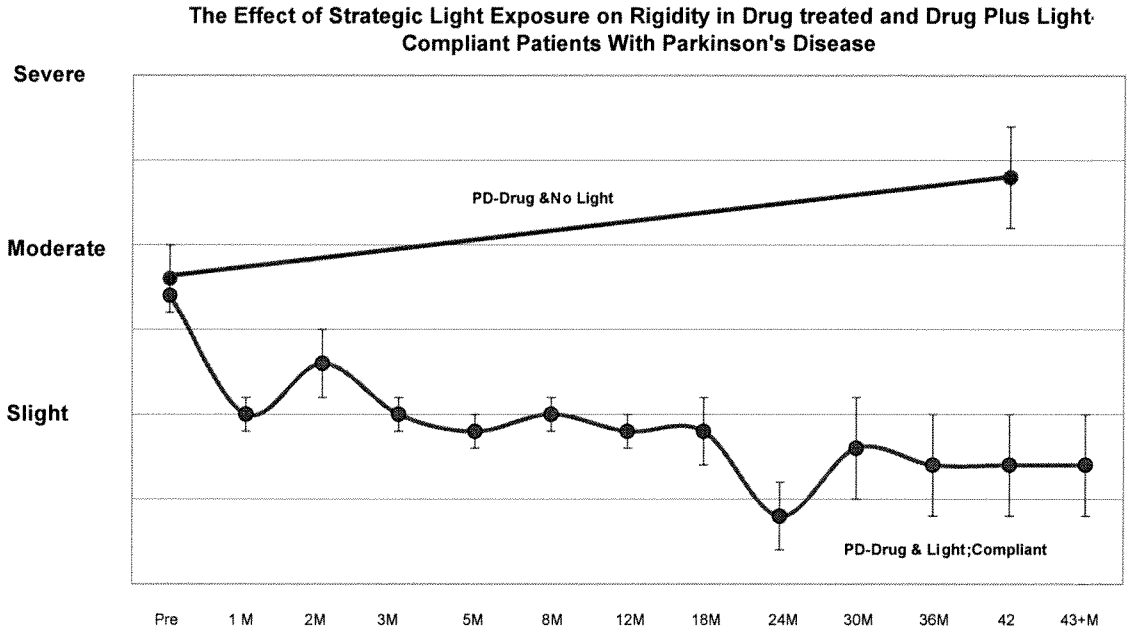
The Effect of Strategic Light Exposure on Rigidity in Drug treated and Drug Plus Light-Compliant Patients With Parkinson's Disease
Severe
Moderate
Slight
PD-Drug &No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 12

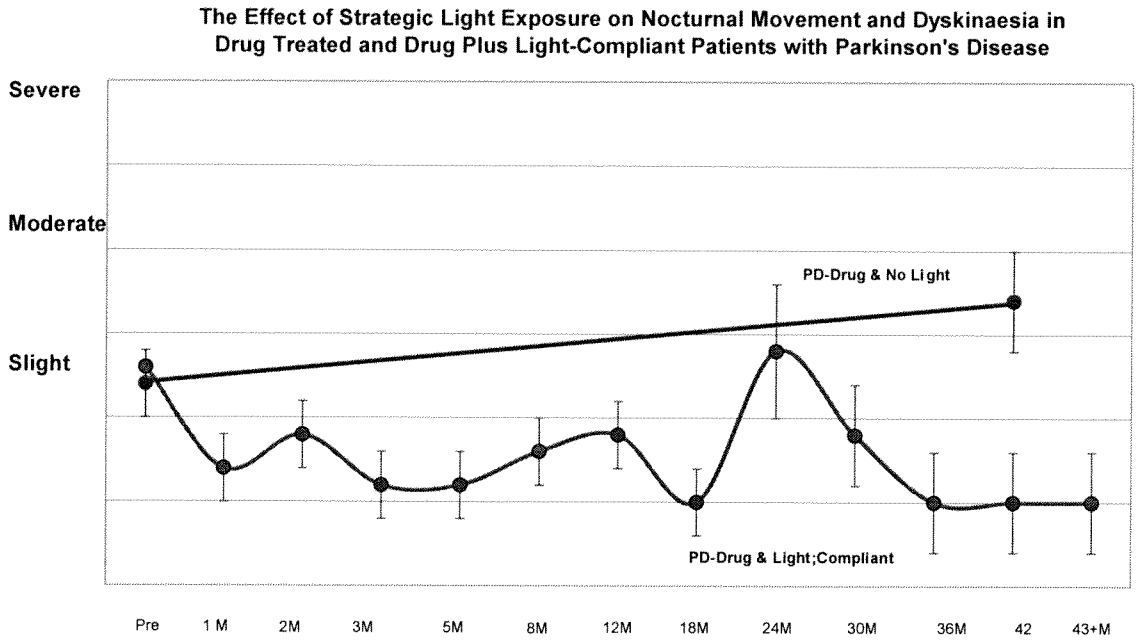
The Effect of Strategic Light Exposure on Nocturnal Movement and Dyskinaesia in Drug Treated and Drug Plus Light-Compliant Patients with Parkinson's Disease
Severe
Moderate
Slight
PD-Drug & No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 13

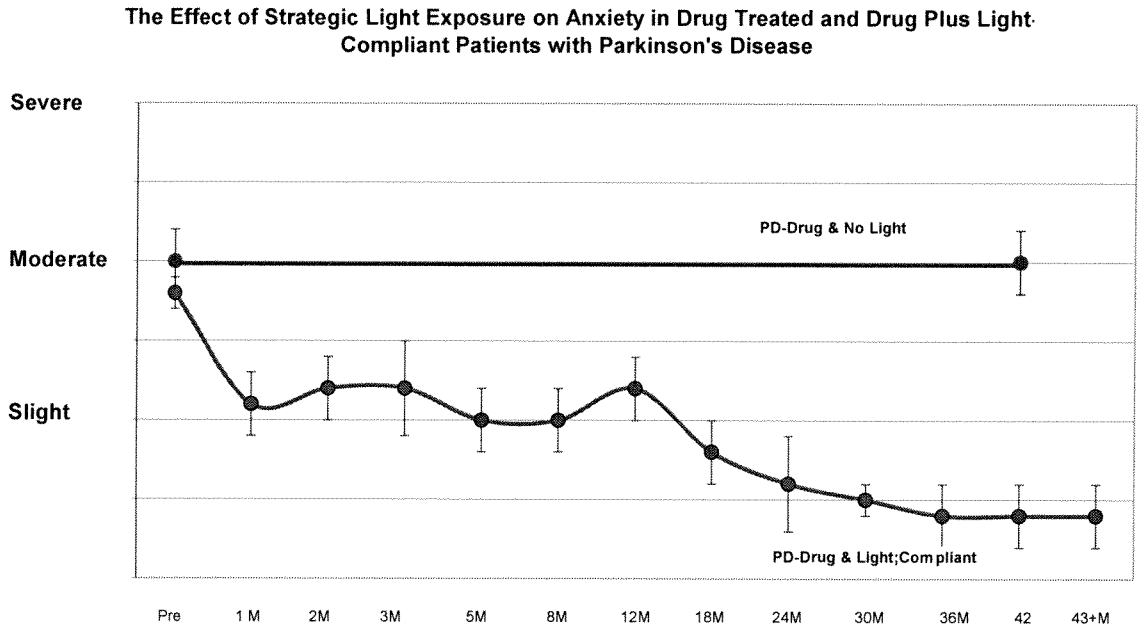
The Effect of Strategic Light Exposure on Anxiety in Drug Treated and Drug Plus Light-Compliant Patients with Parkinson's Disease
Severe
Moderate
Slight
PD-Drug & No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 14

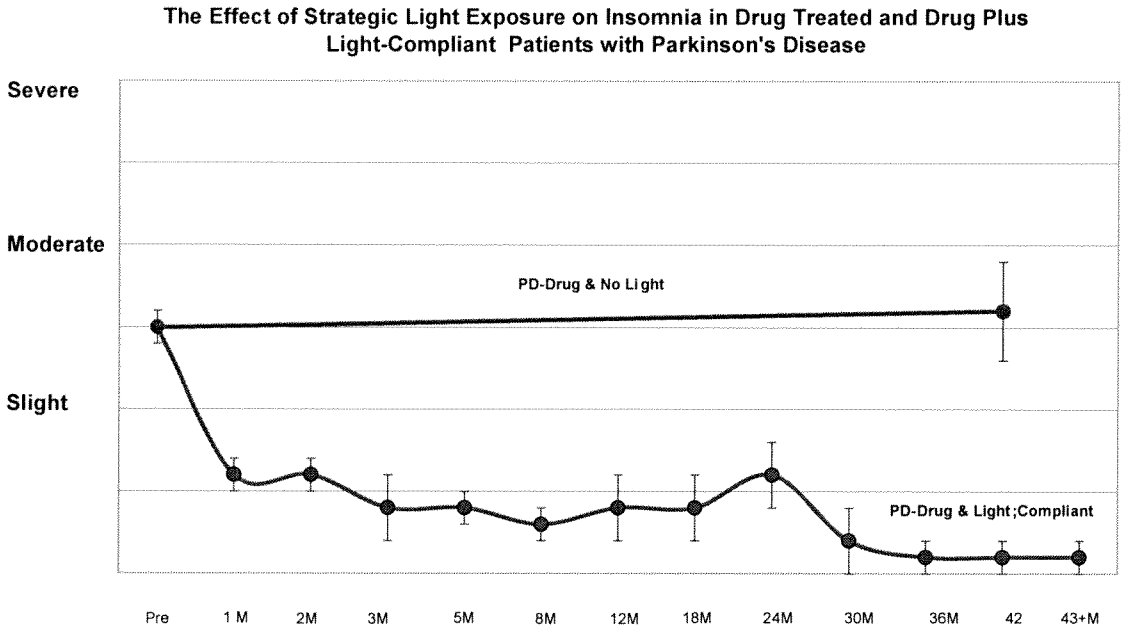
The Effect of Strategic Light Exposure on Insomnia in Drug Treated and Drug Plus Light-Compliant Patients with Parkinson's Disease
Severe
Moderate
Slight
PD-Drug & No Light
PD-Drug & Light;Compliant
Pre
1 M
2M
3M
5M
8M
12M
18M
24M
30M
36M
42
43+M

Fig. 15

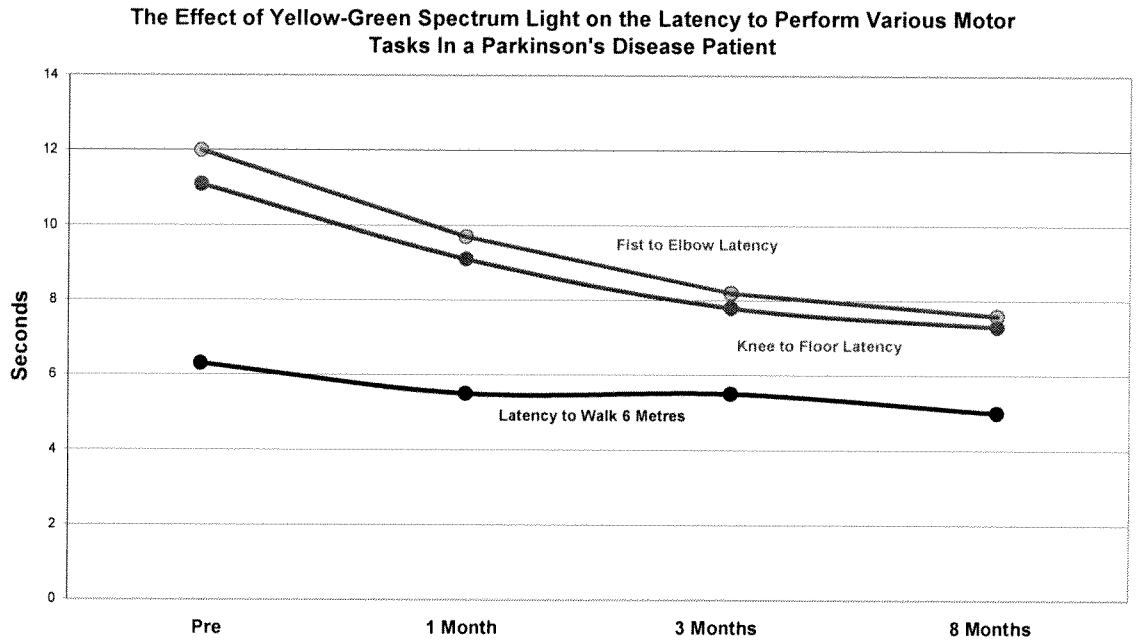
The Effect of Yellow-Green Spectrum Light on the Latency to Perform Various Motor Tasks In a Parkinson's Disease Patient
Seconds
14
12
10
8
6
4
2
0
Fist to Elbow Latency
Knee to Floor Latency
Latency to Walk 6 Metres
Pre
1 Month
3 Months
8 Months

Fig. 16

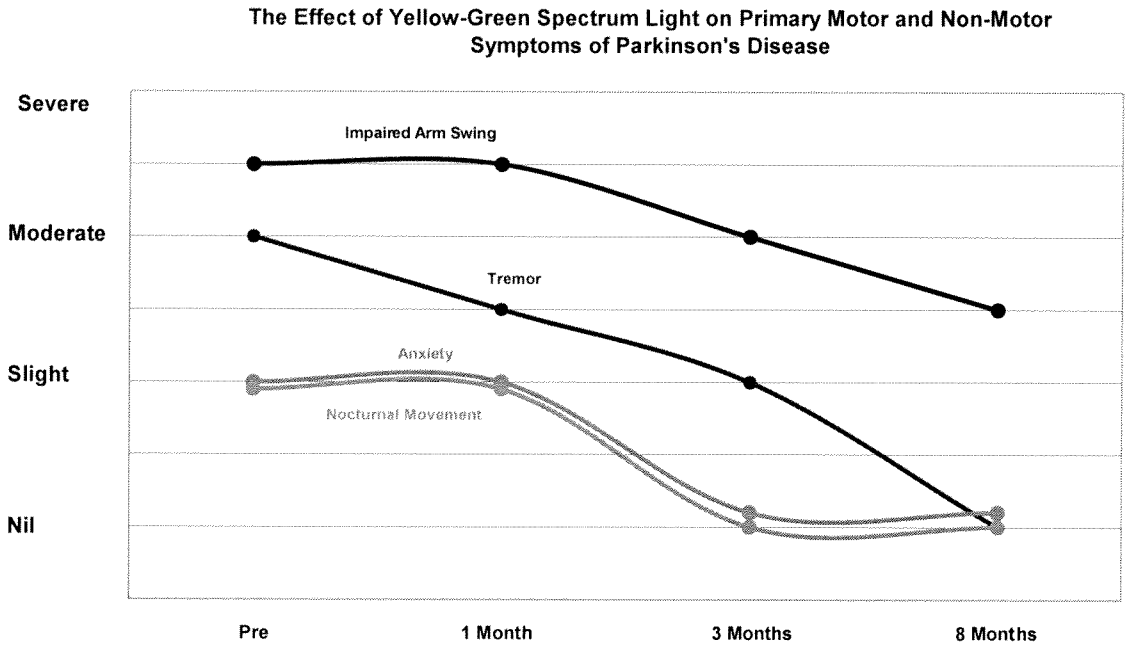
The Effect of Yellow-Green Spectrum Light on Primary Motor and Non-Motor Symptoms of Parkinson's Disease
Severe
Moderate
Slight
Nil
Impaired Arm Swing
Tremor
Anxiety
Nocturnal Movement
Pre
1 Month
3 Months
8 Months

Fig. 17

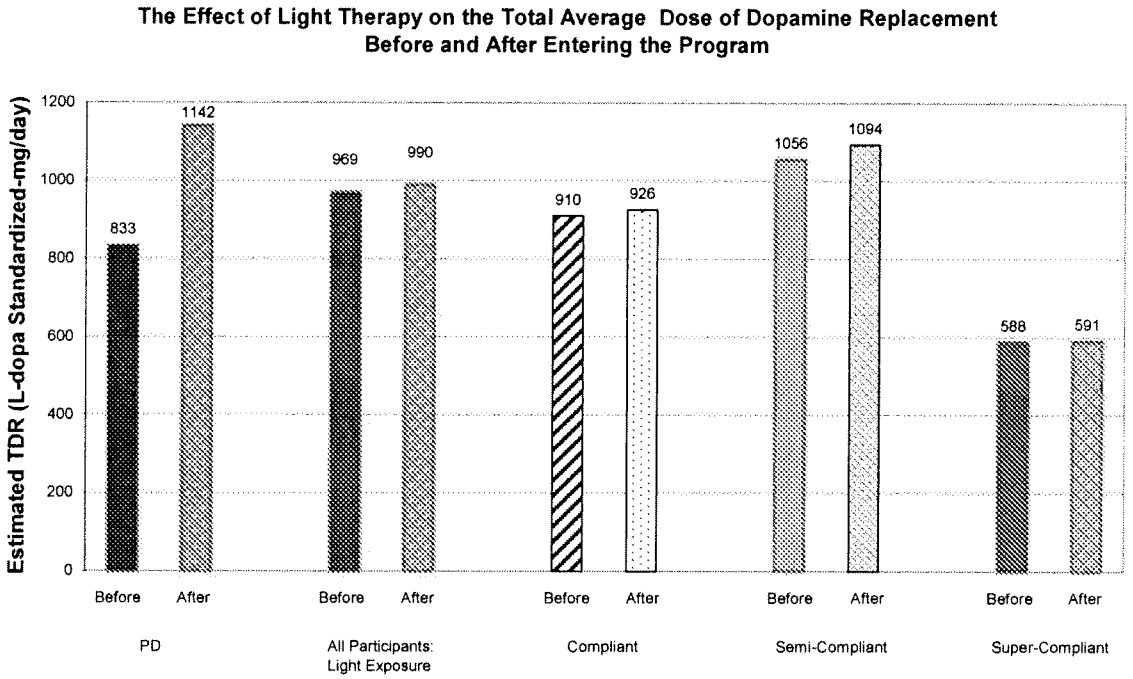
The Effect of Light Therapy on the Total Average Dose of Dopamine Replacement
Before and After Entering the Program
Estimated TDR (L-dopa Standardized-mg/day)
1200
1000
800
600
400
200
0
833
1142
969
990
910
926
1056
1094
588
591
Before
After
PD
All Participants:
Light Exposure
Compliant
Semi-Compliant
Super-Compliant

Fig. 18

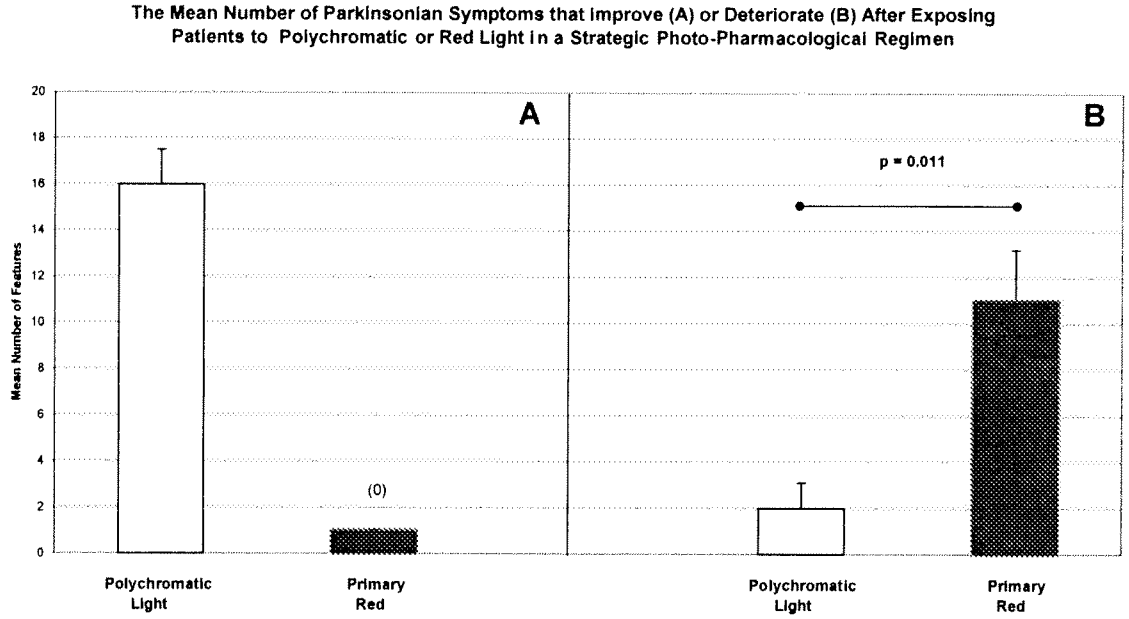
The Mean Number of Parkinsonian Symptoms that Improve (A) or Deteriorate (B) After Exposing Patients to Polychromatic or Red Light in a Strategic Photo-Pharmacological Regimen
Mean Number of Features
A
B
p = 0.011
(0)
Polychromatic Light
Primary Red
Polychromatic Light
Primary Red

Fig. 19

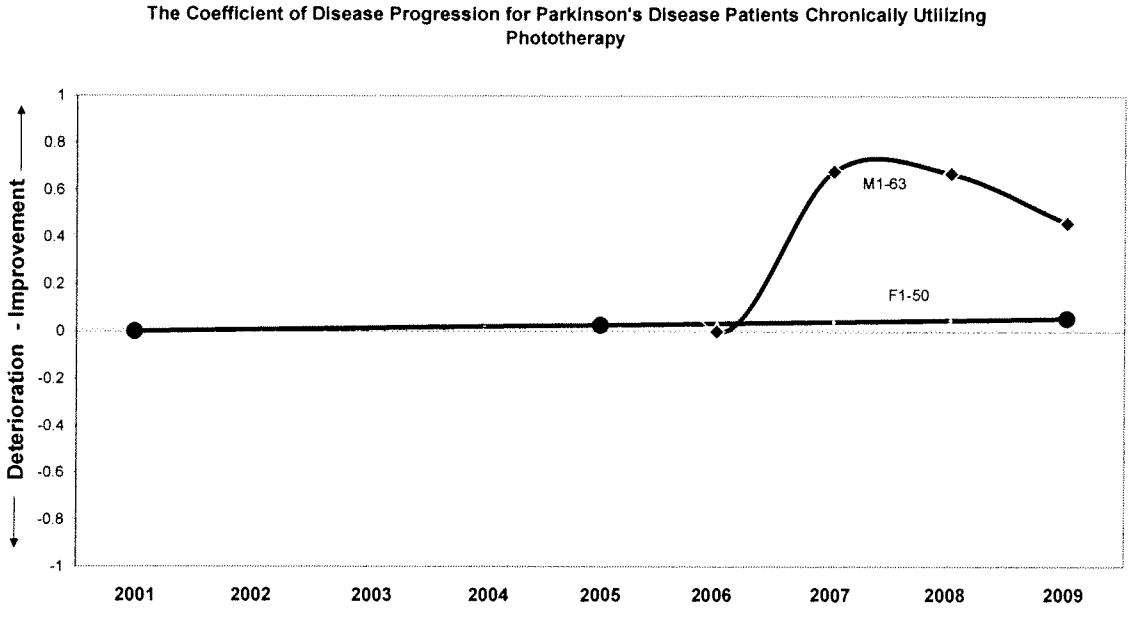
The Coefficient of Disease Progression for Parkinson's Disease Patients Chronically Utilizing Phototherapy
Deterioration - Improvement
M1-63
F1-50
2001
2002
2003
2004
2005
2006
2007
2008
2009

Fig. 20

The Relative Potency of Dopamine Replacement Strategies for Determining Effective Dosing, Overdosing and Total Drug Burden (TBD) in Parkinson's Disease

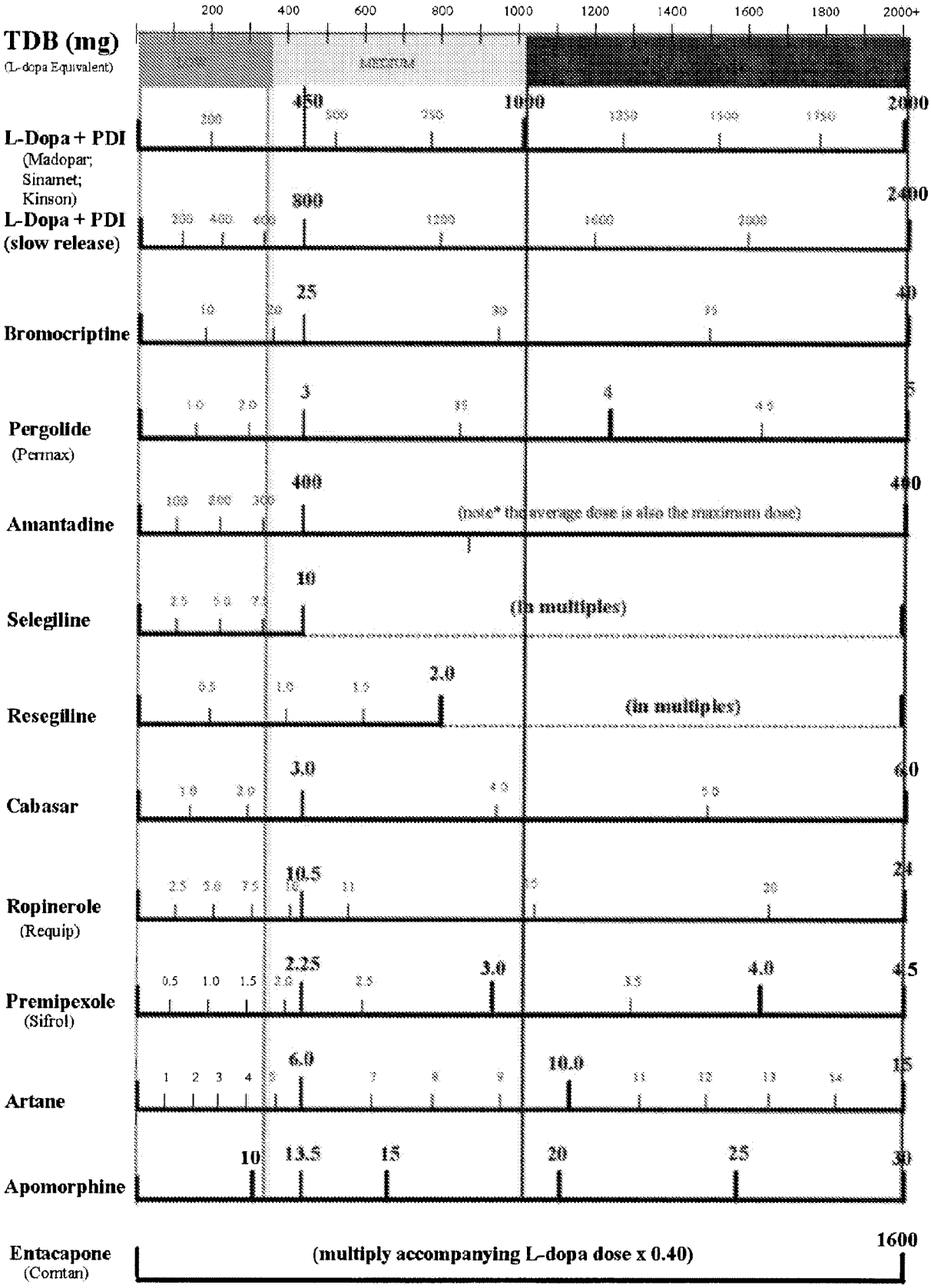

Fig. 21

The Effect of Light Therapy on the Total Average Dose of Dopamine Replacement Before and After Entering the Program