A programmable adaptive resistance exercise system and method. New type of resistance allows a user to maximize amount of muscle growth benefit while minimizing the effort to attain that level. Resistance level may be controlled by computer based on position or any derivate thereof with respect to time. Resistance is adaptive since force level used throughout exercise range is based on current and past performance data. Level of effort and force versus time profile combinations are unlimited. Rest calculated based on the current and past performance data. May utilize hardware having a motor, an exercise interface (such as an bar or handle for example), a position sensor, digital input device to identify someone, computer configured to control the motor and exercise interface using current and past personal training data, calculate an exercise program based on preference and a time for subsequent workout, optionally alert a user when time to workout.
Figure 6

601 Identify User
602 Retrieve Past Personal Training Information
603 Load Exercise Program
604 Accept User Force Imparted on Exercise Interface
605 Monitor Position Signal
606 Record Position Signal
607 Monitor Force Signal
608 Record Force Signal
609 Control Motor to Counteract User Force
610 Adapt Ratio of Force v. Displacement Based On Past Personal Training Information
611 Display a Rest Period
612 Prompting User to Initiate Subsequent Effort
PROGRAMMABLE ADAPTABLE RESISTANCE EXERCISE SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] Embodiments of the invention relate generally to the field of exercise equipment and the methods of use thereof. More particularly, but not by way of limitation, one or more embodiments of the invention enable a programmable adaptive resistance system and method based on present and past training information for a particular user.

[0003] 2. Description of the Related Art

[0004] There are many health benefits associated with exercise. The health and fitness industry offers a wide variety of products and services designed to improve these benefits. One theory of muscular development is that muscles must be contracted past their normal range of capability in order to improve the fitness gains afforded by general exercise.

[0005] In order to stress a muscle, contraction is performed against some sort of resistance. Theoretically, by increasing the resistance against which the muscle is contracted, any desired amount of stress may be achieved. A wide variety of techniques, schemes, and systems are used in various forms and combinations to provide and quantify the resistance used to oppose the muscle contraction. If the level of stress applied is greater than that which the muscle can readily tolerate then the muscle is said to be overloaded.

[0006] There are several types of resistance that may be employed for stressing and overloading muscles. The simplest form of resistance that can be applied to an exercise is that of employing a user’s own weight in a way that causes the muscle to contract against that weight so that stress (and possibly overload) may be achieved. Examples of such exercise would be a push-up, a sit-up, or a deep knee bend. By using the body’s own weight, the need for additional equipment is avoided. However, such exercises are very limited in scope and therefore overall effectiveness.

[0007] By the addition of other weights, for example free weights, many more variations of movement can be performed. Because the muscle contraction is exerted against these external weights, more stress may be applied to a given muscle than would normally be applied by simply doing the same movement without the extra weight. The first form of resistance would then be called the dead weight (or free weight). Here, the force applied is that of gravity against the mass of the weight itself in a downward direction. If the range of motion is up and down, the resistance force is constant throughout the range of motion. An example of such an exercise would be a bench press of a barbell weight. As the amount of free weight is increased, control becomes more critical. The weight must be moved safely in order to apply a safe and proper amount of overload. Excessive overload can cause failure of the muscle and injury to the body. One of the features of using free weights is that exercises using free weights engage stabilization muscles in addition to the muscle being exercised. This feature becomes a limitation when an injured muscle is called upon to stabilize a free weight movement when exercising a desired muscle. Thus, it is important to limit the use of free weights when working muscles near injured muscles. For example, when performing bench press a shoulder injury may prevent a person from overloading the pectoral muscles since the injured shoulder may generate great pain and not allow stabilization to be provided for the exercise.

[0008] In order to afford large amounts of resistance while more easily maintaining control of an exercise, existing solutions have also employed spring resistance. This form of resistance allows larger amounts of force to be applied in the direction of movement regardless of whether that movement is up and down or in some other direction. This advantage allows greater resistance and greater safety, as well as greater flexibility in machine design because the resistance can be applied without regard to the orientation to the floor. However, the resistance of a spring weight is variable, increasing linearly as the distance of spring stretch or “displacement” is increased. In many movements, the variation in resistance that is lower at the beginning of travel and ever increasing as the displacement is increased, imposes an additional limitation to the design of the exercise. The particular profile of increasing resistance with displacement is not optimum for most normal body movements.

[0009] In the 1970’s, the concept of variable resistance became widely accepted. Unlike free weights with fixed resistive force or springs with ever increasing force, the variable resistance machine employs a cable and cam system to produce a variable resistance profile. As the muscle moves throughout its range of motion, the changing radius of the cam adjusts the effective weight and thereby the level of resistance. The variable cam may produce virtually any resistance profile as long as the resistance increased, or only slightly decreased over the range of motion. Any particular exercise would always have an associated variation in strength throughout the range of motion. The cam (and resulting resistance variation profile), is generally matched to the relative strength of the muscle under load. This variation affords greater stress to the muscle for a given duration of movement cycle repetition resulting in improved exercise efficiency. These machines, marketed under the trade name Nautilus™ have gained acceptance and many variations built using this technique are still in fairly wide use today.

[0010] A second form of variable resistance is provided by the hydraulic cylinder. Similar to a shock absorber in a car, this simple and inexpensive device offers resistance to motion in proportion to the speed of the motion. If used in an exercise machine, the hydraulic cylinder causes the resistance to increase if the exercise movement is done at greater speed. The operator can, after much practice, create a varying resistance of complex nature by simply moving the device at greater or lesser speed at different positions in the exercise cycle. Unfortunately, because the actual resistance is difficult to control and quantify, the amount of actual stress (and therefore overload) is difficult to predict or measure. Additionally, such motion that is resisted in proportion to velocity of travel is very unnatural. Some users do not accept this type of resistance as an alternative to the more natural feel of free weights or spring systems.

[0011] Regardless of the type of resistance used, the actual amount of stress experienced by the muscle is determined by the contraction force of the muscle and the amount of time during which the force is applied. The concept of force-time (the product of force and time) as a measure of muscle stress
is somewhat controversial. For example, it is not clear whether force-time is a linear product. For example, it is not clear how a 100 lb force for 4 seconds of muscle stress differs from a 50 lb force for 8 seconds. Although there is disagreement as to the actual quantification, most do agree that if the resistance level is reduced, that resistance must be applied for a longer time to achieve the same level of muscle stress.

[0012] The amount of stress required to overload a muscle is proportional to the capacity (size and fatigue level) of the muscle. A larger, stronger muscle that is well rested will require a greater amount of applied stress (resistance force-time) to produce a given amount of overload. It is believed that overload, not stress, is the critical factor in determining the level of growth benefit of a particular exercise to a particular muscle.

[0013] Conventional exercise systems monitor the amount of force which is exerted by user and employ a feedback loop to provide a proportional amount of resisting force to custom configure the resistant force to the individual and to the actual muscular strength available at each point over a given range of movement. Such systems have conventionally employed a current controlled torque motor under direct program control of a computer to precisely vary the force of resistance to muscular movement.

[0014] Conventional systems require that a user follow preselected patterns of routines, including speed, force, and rates of variation therein, which may not be best suited for user training goals and performance history of a user. The main problem with conventional exercise systems available today is that they do not provide a way to automate the process of providing customized exercise program and tracking individuals over time and adapting the workout program as a user's physical condition and/or strength changes.

[0015] No known strength training exercise system or method uses historical performance data from a user to adapt a workout session. In addition, no known system or method automatically calculates rest times based on present and past personal training information. The methods in use generally rely on manual efforts and guess work that are external to an exercise apparatus. The manual steps comprise various combinations of testing and experimentation, mostly hit or miss, trial and error, resulting in greater or lesser levels of training success. As these manual techniques are applied, there are inevitable tradeoffs between efficiency and complexity of execution.

[0016] U.S. Pat. No. 4,930,770 to Baker describes an exercise apparatus that varies resisting force by position using a variable torque motor. This apparatus does not contemplate use of historical and present performance data to adapt the exercise.

[0017] U.S. Pat. No. 4,934,694 to McIntosh describes an exercise apparatus with an improved variable force exercise system that uses a current mode switching technology to accurately control the motor torque using only electrical signals, which thereby increases the response time of the system by a large factor. The system sets a preprogrammed variation in motor torque over a range of movement of an exercise member into rotation of a motor driveshaft, by setting a preprogrammed range of motor current variations. The system allows for adaptive response of changing the resisting torque automatically by the system due to the decrease in performance by a user. The system does not contemplate an automated process of recording a user's performance data and automatic analysis of the user's historical performance data for the design of subsequent workout sessions.

[0018] U.S. Pat. No. 5,431,604 to Panagiotopoulos, et al., describes an exercise apparatus with a DC torque motor which is electronically controlled to provide the exact amount of force necessary to permit the user to exercise past the point of initial muscle failure. The device including means for continuously sensing the condition of the user, and substantially adjusting the degree of torque to respond to the sensed condition. This patent has only one mode of operation, which is to automatically adjust and decrease the resistance as the user progresses through a set of exercises and gradually begins to approach muscle failure. This patent does not contemplate use of a historical performance data for the design of subsequent workout sessions.

[0019] Therefore there is a need for a system and method that automates the training process to provide new levels of performance efficiency which is based on the user's current and historical performance data.

BRIEF SUMMARY OF THE INVENTION

[0020] One or more embodiments of the invention enable a programmable adaptive resistance exercise system and method. This new type of resistance allows a user to maximize the amount of muscle growth or endurance or allows a user to perform fitness maintenance or injury recovery while minimizing the effort expended to attain the desired level of benefit. The resistance force level is programmable in that the force applied by the system can be adjusted dynamically under computer control. For example, the resistance force level may be controlled via a computer based on position or any derivate thereof with respect to time such as velocity, acceleration, jerk, etc. The resistance force level is adaptive since embodiments of the invention provide a resistive force level throughout the range of an exercise based on current and past historical performance data associated with a particular user. Past historical performance data is also known as past personal training information. The force versus displacement and/or time profiles used with embodiments of the invention are user specific and may be applied at different force levels to attain the type and quantity of resistance desired (growth, endurance, maintenance, injury recovery, etc.). Rest periods may be calculated based on the current and past personal training information to further optimize growth benefit while minimizing the effort expended. Embodiments of the invention may utilize hardware comprising a motor, an exercise interface, a position sensor, a force sensor, a digital input device, a computer configured to control the motor and hence the exercise interface (such as an bar or handle for example) using current and past historical personal training information and calculate an exercise program based on a user preference. Methods of embodiments of the invention may also include notifying the user of a rest time and optionally alerting a user when it is time to begin a subsequent workout.

[0021] In one or more embodiments of the invention the system measures a user's performance, for example the user
force applied through a displacement and time, at the start of a training program. The system measures the initial performance using a standardized set of movements against a resistance force level and generates a profile of the resistance force level with respect to displacement of the exercise interface. The system adjusts the resistance level for each muscle movement to stress the muscles in a way that allows the system to measure and record the particular level of fitness (capacity) for that particular movement and that particular user. The system is configured to accurately measure the position and derive or measure force and obtain the force versus time and the force versus displacement curves of a particular exercise movement. The system measures force versus time and force versus displacement using a position sensor (that may be integrated with a motor) and measuring current used by a motor to deduce force, or optionally using a force sensor to directly measure force.

[0022] Once the initial fitness level is quantified, the first workout session begins. The system provides customized sets of exercises with customized resistance force levels, i.e., profiles of programmable adaptive resistance for a given user. The programmable adaptive resistance levels generate the optimum level of stress for the first exercise session for that particular user. The system monitors the performance level during the first workout and determines when the workout should end. Performance data known as present personal training data is stored and automatically analyzed by the system to be used in the design of subsequent exercise programs or workout sessions. Since a first workout session may make a user sore, individuals that may have never worked out before may be given a gradual increase in resistance level over an extended number of workout sessions so that the user’s connective tissue can strengthen before overstretching or overloading the muscles. Any algorithm may be used that adapts the resistance level based on current and past personal performance information related to the particular user.

[0023] Subsequent workout sessions are designed by application of a profile using the baseline data stored during the initial and first workout sessions. For subsequent workouts, as the number of workout sessions increases, the system begins to accumulate a comprehensive performance history for the particular user. The system schedules a time for the next workout based upon the performance level, overload level and amount of recovery time suggested for maximum muscle growth (or other workout goal) while maintaining minimum expended exercise effort. Other algorithms may be utilized that optimize endurance, fitness or are designed for injury recovery as well. An exercise program comprising the various ratios of maximum performance and number of repetitions and number of sets may be selected. For example, the desired exercise program may be based on the user’s fitness goals, age, time of day at which exercise occurs, or any other factor that is current or historical with respect to the user. As more workouts occur, the history database comprising past personal training information becomes more refined. The resistance force levels of programmable adaptive resistance as well as the rest period duration accuracy are adjusted to continuously advance the users fitness level while minimizing the number of workouts and duration of each workout.

[0024] At any time during the exercise program, the system may provide a user with performance data in the form of progress reports. This type of information provides motivation to the user and/or trainer. The system allows the user (or trainer) to optionally select or alter the level of progress desired. The system instructs and prompts the user during the workout to assure that the desired profile is always performed accurately. The user maintains control over the exercise program by optionally providing additional selections and preferences which are combined with the system’s prediction of fitness level based on current and past personal performance information to determine the actual exercise program and level and profile of programmable adaptive resistance for each workout.

[0025] For network capable apparatus, the progress report may be emailed to the user, may be placed on a website that is accessible for example to the user after entering a password, or via text messaging. The progress report may show graphical percentage rates of improvement of absolute levels of performance for example. Any type of report that is based on the user’s past personal training information is in keeping with the spirit of the invention.

[0026] In addition, the particular exercise program utilized by a user denotes the type of exercise goals that the user is interested in achieving. The system may suggest food or beverage regimes and may also market food, food supplements, beverage or other products that may be utilized by the user to better achieve their exercise goals. Marketing products to users with strength related exercise goals may include sending the user mail, email or other communications such as text messages that allow for the protein powder or weight gain compounds to be presented to the user. Marketing products to users with endurance related exercise goals may include providing coupons to users for carbohydrate drinks or energy bars. Marketing products to users with injuries may include alerting the user buy a hot/cold pad at the exercise facility or by mail order. Any method of marketing products to users based on their current and past personal training information is in keeping with the spirit of the invention.

[0027] Since the system keeps track of training information measured when a user exercises using an embodiment of the invention, the user may be provided with rewards for improvement or reaching certain goals or outperforming other users for example. Rewards may include coupons for free or discounted products or any other reward.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The above and other aspects, features and advantages of the invention will be more apparent from the following more particular description thereof, presented in conjunction with the following drawings wherein:

[0029] FIG. 1 shows a system view of an embodiment of the invention.

[0030] FIG. 2 shows force as a function of displacement for an exercise interface that is displaced through a distance D along the horizontal axis and where force is displayed along the vertical axis.

[0031] FIG. 3 shows force as a function of time for the same exercise interface displacement where force is displayed in the vertical axis as in FIG. 1, while time is displayed along the horizontal axis.
FIG. 4 shows a force versus displacement graph of a workout set comprising multiple repetitions at fractional resistance force levels.

FIG. 5 shows one method of summing all force versus time integrals for all repetitions of at least one set.

FIG. 6 shows an embodiment of a method for providing programmable adaptive resistance.

**DETAILED DESCRIPTION**

A programmable adaptive resistance exercise system and method will now be described. In the following exemplary description numerous specific details are set forth in order to provide a more thorough understanding of embodiments of the invention. It will be apparent, however, to an artisan of ordinary skill that the present invention may be practiced without incorporating all aspects of the specific details described herein. In other instances, specific features, quantities, or measurements well known to those of ordinary skill in the art have not been described in detail so as not to obscure the invention. Readers should note that although examples of the invention are set forth herein, the claims, and the full scope of any equivalents, are what define the metes and bounds of the invention.

A system view of an embodiment of the invention is shown in FIG. 1. Embodiments of the invention provide programmable adaptive resistance force levels by measuring a user’s fitness in an initial workout and then providing adaptive resistance force levels in subsequent workouts using the previously measured training data or information. The resistance level of effort produced by an embodiment of the invention is shown as a function of force versus displacement and/or time, e.g., a profile (also known as past performance training information). Embodiments of the invention may utilize this data in any programmable manner for example to target a specific type of resistance desired (growth, endurance, maintenance, injury recovery, etc.). Rest periods may be calculated based on the current and past personal training information to further optimize growth benefit while minimizing the effort expended. In order to target an exercise program at a particular user, the system identifies the user and retrieves past personal training information for the user. In environments where the multiple users will use a particular embodiment of the invention, each embodiment of the invention may comprise a database that is local or a network interface to retrieve past performance training information from an external database. Embodiments of the invention may further comprise hardware including motor, an exercise interface (as shown handles for a bench press for example), a position sensor (that may be integrated into motor or external to motor), an optional digital input device, computer configured to control motor and hence exercise interface using current and past historical personal training information. The system is configured to calculate an exercise program comprising a number of repetitions at fractional force levels and a number of sets based on a user preference and notify the user of a rest time duration. In addition, the system may optionally alert a user when it is time to begin a subsequent workout. An optional force sensor may be included in the system if the motor is not calibrated to indicate the amount of force applied to the exercise interface based on applied motor power for example.

The programmable adaptive resistance exercise system enables new methods of exercise tailored to a user. This new type of resistance allows a user to maximize the amount of muscle growth or endurance or allows a user to perform fitness maintenance or perform injury recovery while minimizing the effort expended to attain the desired level of benefit. The resistance force level applied is dependent upon displacement and/or time and is specific to a particular user. For embodiments that are utilized by more than one person, identification is obtained by the system to retrieve the proper past personal training information associated with the particular user. For example with a key pad having depressible keys, voice recognition, an RFID reader, a bar code reader, a biometric reader or any other type of identifying device coupled with computer. For single user embodiments, identifying the user can be performed by identifying that the user is beginning to use the system. The resistance force level provided by embodiments of the invention is programmable since it can be adjusted dynamically under computer control. For example, the resistance force level may be controlled via computer based on displacement “d” or any derivative thereof with respect to time “t” such as velocity, acceleration, jerk, etc. The resistance force level is adaptive since embodiments of the invention provide a resistive force level throughout the displacement range of an exercise based on current and past historical performance data associated with a particular user. FIG. 2 shows force as a function of displacement where an exercise interface is displaced through a distance D along the horizontal axis and where force is displayed along the vertical axis. FIG. 3 shows force as a function of time where force is displayed in the vertical axis as in FIG. 2, while time is displayed along the horizontal axis. Note that if the speed at which a particular user performs an exercise is absolutely constant then the two shapes will coincide when normalized in the horizontal axes. In the example shown in FIGS. 2 and 3, the user moves slightly slower at peak exerted force meaning that the curve in FIG. 2 is slightly flatter than the curve in FIG. 2. Note that FIGS. 2 and 3 show full displacement in one direction only and not in the return direction.

In one or more embodiments of the invention the system measures a user’s performance, for example the user force applied through a displacement and time, at the start of a training program in an initial workout session. One embodiment of the measurement process allows the exercise interface to move at a desired velocity as a user imparts maximum effort against the exercise interface such that the displacement of the exercise interface occurs in one second. Values for the displacement other than one second are in keeping with the spirit of the invention as one skilled in the art will recognize. The exercise interface is provided with a resistance force that is adjusted in real-time to maintain the velocity within a range that is as close to constant as the particular embodiment of the apparatus allows. Therefore, regardless of the amount of user force applied, the exercise interface is displaced to the full range of displacement “D” associated with a particular user (e.g., depending on the length of the user’s arms or legs or range of motion through a joint). In one embodiment, the displacement in the reverse direction during initial calibration is traversed with a greatly reduced resistive force to allow for the exercise interface to return to its original position. As the exercise interface is displaced, force versus displacement curve is recorded. The system samples either directly or indirectly the user
force applied against the exercise interface. This may be performed by measuring the amount of current passing through the motor, or through use of a force sensor coupled with the exercise interface or motor-exercise interface junction for example. Any method of measuring force through the displacement of the exercise arm is in keeping with the spirit of the invention. The force and displacement are sampled at sample rates that are configurable in one or more embodiments of the invention. The displacement may be measured through the motor or using a position sensor coupled with exercise interface 103 for example. More or fewer samples may be sampled per second to provide more accurate or cheaper embodiments for example. The recorded force versus displacement curve indicates the variable resistance force level profile associated with the particular user and exercise. The initial maximum effort force versus displacement curve is saved for each movement and for later use. The total effort is calculated by integrating the force applied for each sample per unit time and saved as a baseline strength level.

[0039] After calculating the baseline strength level (i.e., the sum of force samples*time intervals), the system provides the user with a rest period. The rest period for example may be in units of minutes or hours or any other time unit. After the rest period is complete, the movements may be performed again using a time period of two seconds for full displacement of the exercise interface for example. A force versus displacement graph of a workout set comprising multiple repetitions at fractional resistance force levels is shown in FIG. 4. Any other value for the time period for full displacement is in keeping with the spirit of the invention. The return displacement may be set to the same interval of two seconds or any other time period that may or may not be equal to the opposite displacement for example. In either case, displacement “D” in the return direction is generally the same as the original displacement in the opposite direction. The resistance level applied through the force versus displacement curve is scaled to a fraction “R” of the initial force versus displacement curve measured during the initial workout which is shown as baseline force level “B”. The return resistance level for any repetitions may be less than, greater than or equal to the opposite resistance level. In FIG. 4, initial displacement of the first repetition has a resistance force versus displacement graph 401 that is shown at initial force ratio “R” which is a fractional force ratio with respect to baseline force “B”. Graph 401 represents the force that is applied as the user moves the exercise interface to displacement “D”. The resistance force level of return portion 402 of the first repetition is shown with a slightly smaller ratio making the return portion of the repetition slightly easier. This need not be the case and is shown for ease of illustration so that it is clear that once the exercise interface moves to displacement “D” it then returns to displacement 0. Graph 401 and 402 make up the first full repetition of the set. As shown there are 5 full repetitions culminating in return repetition with force versus displacement graph 410.

[0040] An initial resistance ratio “R” for example between 3% and 60% (as shown 60%) of the user force obtained at the initial workout session, e.g., “B” may be used in one or more embodiments of the invention. The user may be provided with a resistance force level ratio or “R” or a gradually decreasing fraction thereof for as many repetitions until the user begins to fatigue. As the user begins to struggle with the resistive force generated by the system, the system reduces the resistance force level until a half level point “R/2” is reached. For example if the first movement of the exercise interface was applied against a resistance force of 60% of the force levels of the initial force versus displacement curve, then fatigue when the ratio reaches half of the initial ratio, i.e., when the ratio is 30%. The pace of repetitions is held constant while the ratio is reduced in one or more embodiments of the invention. During each repetition, the integral of force over time is saved as a per repetition strength level. The sum of all repetition strength levels is calculated and saved as a baseline endurance level. In addition, the ratio initially selected “R” and the number of repetitions before fatigue may be saved for later use. If for example the initial repetition uses a 100 newton (on average) force for 2 seconds and the subsequent repetitions use 90, 80, 70 and 60 newton forces for 4 seconds each (2 seconds to displace and 2 seconds to return), then the baseline endurance is the sum of these numbers, namely 100+90+80+70+60 which equals 400. This value multiplied by 4 seconds yields a baseline endurance level of 1600 newton seconds, with a number of repetitions to fatigue of 5, initial ratio “R” of 60% and ending ratio “R/2” of 30%. This example shows a low number of repetitions, however any number of repetitions may be utilized depending on the workout goal of the particular user.

[0041] The system can calculate the ratio to use with respect to the force versus displacement curve at maximum user effort in order to target a number of repetitions. For example, if the initial ratio chosen was 40% and this resulted in a halfway point of fatigue that required 25 repetitions, then the ratio “R” may be chosen higher in order to decrease the number of repetitions back into the range appropriate for the exercise program selected by the user (strength, endurance, etc.). By setting a ratio for example of 60% for strength conditioning, a smaller number of repetitions generally occur before user fatigue. In this manner an exercise program can be generated that comprises a number of sets having a number of repetitions per muscle group exercised by the user. For particular body parts such as legs, a higher number of repetitions may be desired compared to arms. For a typical upper body exercise program a nominal value of 15 repetitions per set may be targeted. If the user begins to become fatigued before the calculated number of repetitions, then the system can lower the ratio further for example in order to end at 15 repetitions. For example, during the exercise, the ratio may be lowered for each repetition (or during a repetition as well) in order to ensure that 15 repetitions are achieved in order to roughly obtain the baseline endurance level previously calculated in the initial workout. A current endurance level composite value comprising three values is created by 1) saving the ending ratio actually utilized in the last repetition with respect to the first ratio used, 2) saving the number of repetitions the user was able to achieve and 3) saving the ordered set of ratios used, for example 60%, 52%, 47%, 39% and 30%. If the ratios are linearly decreased then the ratios would differ by (R-R/2)/(N-1) where N is the number of repetitions in one embodiment of the invention.

[0042] Once the initial fitness level is quantified as described above, the first full workout session begins. The system provides customized sets of exercises with customized resistance force levels and profiles of programmable adaptive resistance for a given user. The programmable adaptive resistance levels generate the optimum level of
stress for the first exercise session for that particular user. The system monitors the performance level during the first workout and determines when the workout should end. Performance data is stored and automatically analyzed by the system to be used in the design of subsequent exercise programs or workout sessions. Since a first workout session may make a user sore, individuals that may have never worked out before may be given a gradual increase in resistance level over an extended number of workout sessions so that the user’s connective tissue can strengthen before overloading the muscles. Any algorithm may be used that adapts the resistance level based on current and past personal performance information related to the particular user. In one or more embodiments of the invention, the system may utilize performance information from another user or group of users that may be similar to the particular user. For example, past performance data for another user (perhaps of relatively the same age, weight, etc.) with similar workout goals may be utilized to adapt the workout in order to optimize the results for a particular user based on the results observed from other user or group of users. The capability to adapt the workout for a particular user allows for any type of algorithm to be used and as such the particular algorithm used for a particular user may vary over time. Any algorithm that is adapted based on historical performance or predicted performance based on the historical performance of similar users or users that share at least one common characteristic such as age, weight, height or any other characteristic associated with a user is in keeping with the spirit of the invention. For example, an algorithm that is used for a particular user for a given workout or number of workouts may be altered to induce a user’s body to grow further. One example of altering or adapting an algorithm for a particular user may involve two second extension and retraction intervals. After a number of workouts, the user may observe less gain that in the initial workouts. Altering or adapting the algorithm to a “negative” algorithm where a particular user extends against a given force for two seconds and retracts against a given force for 10 seconds per repetition may increase the stress or overload a user in a different way that optimizes overall results. No one algorithm is therefore the “best” for a particular user for the entire lifespan of a user and as one skilled in the art will recognize, adapting the algorithm for a particular user based on that particular user’s past history and optionally other user’s past performance provides optimal results over time. By using a user or group of users’ past performance data, the algorithm for increasing or decreasing the relative effort for each repetition or time to execute each portion of a repetition may be altered or adjusted to provide the best results as shown to occur in other users.

[0043] Subsequent workout sessions are designed by application of a profile using the baseline data stored during the initial and first workout sessions. For subsequent workouts, as the number of workout sessions increases, the system begins to accumulate a comprehensive performance history for the particular user. The system schedules a time for the next workout based upon the performance level, overload level and amount of recovery time suggested for maximum muscle growth (or other workout goal) while maintaining minimum expended exercise effort. Other algorithms may be utilized that optimize endurance, fitness or are designed for injury recovery as well. A profile may be selected for example based on the user’s age, time of day at which exercise occurs, or any other factor that is current or historical with respect to the user. As more workouts occur, the history database comprising past personal training information becomes more refined. The resistance force levels of programmable adaptive resistance as well as the rest period duration accuracy are adjusted to continuously advance the users fitness level while minimizing the number of workouts and duration of each workout.

[0044] Summing all current endurance level values for each set yields a current endurance sum. FIG. 5 shows one method of summing all force versus time integrals for all repetitions of at least one set. Each repetition in this embodiment of the invention is shown with full displacement and return displacement using the same ratio, i.e., each graph shows 10 repetitions as opposed to FIG. 4. The lower set has lower starting ratio “L” and half value ratio “L/2”. The repetitions 551 through 560 hence have lower force versus time integrals with respect to repetitions 501 through 510. This need not be the case and the ratios R and L and any sets between the first and last set may comprise different ratios that increase, decrease or remain the same between each successive set. The alteration of ratio between sets may be set based on the type of exercise goal that a user has defined for example. The summing of each integral is shown as a sigma symbol to the left of each graph. Summing all of the sums provides an overall effort put forth by the user over all sets.

[0045] As a current endurance level of a particular movement grows over time (e.g., the number of repetitions to fatigue and/or ratios increase, the current rest period may be incremented upwards. A current over-stress factor beginning at 5% for example may be multiplied by each ratio for each repetition to provide overload as time passes and the user becomes stronger. This may for example be applied after an initial warm up set in one or more embodiments of the invention. By saving the time required for a user to perform a set the over-stress factor may be modified to either increase the load if the user is able to maintain a two second per displacement pace, or to leave the over-stress factor as is. For example, if the user is able to remain with 15% of the pace at a particular over-stress factor, then the over-stress factor can be incremented for the next set or workout. If the user for example is unable to keep the pace up, then the system may increase the rest period in one embodiment of the invention. The increase in the current endurance level values is a direct measure of improvement. Other embodiments of the invention may hold the ratio “R” constant over multiple repetitions and time the entire set. If the entire set is slower at a given over-stress factor then the over-stress factor may be left unchanged while the rest period is increased for example. If the entire set is faster at a given over-stress factor then the over-stress factor may be increased and/or the rest period may be decreased. Any algorithm that alters the resistance force levels of the system using past personal performance information is in keeping with the spirit of the invention.

[0046] At any time during the exercise program, the system may provide a user with performance data in the form of progress reports. This type of information provides motivation to the user and/or trainer. The system allows the user (or trainer) to optionally select or alter the level of progress desired. The system instructs and prompts the user during the workout to assure that the desired profile is always performed accurately. The user maintains control.
over the exercise program by optionally providing additional selections and preferences which are combined with the system’s prediction of fitness level based on current and past personal performance information to determine the actual exercise program and level of programmable adaptive resistance for each workout. For network capable apparatus, i.e., computer 104 in FIG. 1 is network enabled or coupled with a network device, the progress report may be emailed to the user, may be placed on a website that is accessible for example to the user after entering a password, or via text messaging. The progress report may show graphical percentage rates of improvement of absolute levels of performance for example. Any type of report that is based on the user’s past personal training information is in keeping with the spirit of the invention.

[0047] In addition, since the particular exercise program utilized by a user denotes the type of exercise goals that the user is interested in achieving. The system may suggest food or beverage regimes and may also market food, beverage or other products that may be utilized by the user to better achieve their exercise goals. Marketing products to users with strength related exercise goals may include sending the user mail, email or other communications such as text messages that allow for the protein powder or weight gain compounds to be presented to the user. Marketing products to users with endurance related exercise goals may include providing coupons to users for carbohydrate drinks or energy bars. Marketing products to users with injuries may include alerting the user buy a hot/cold pad at the exercise facility or by mail order. Any method of marketing products to users based on their current and past personal training information is in keeping with the spirit of the invention.

[0048] Since the system keeps track of training information measured when a user exercises using an embodiment of the invention, the user may be provided with rewards for improvement or reaching certain goals or outperforming other users for example. Rewards may include coupons for free or discounted products or any other reward.

[0049] FIG. 6 shows an embodiment of a method for providing programmable adaptive resistance. The method begins by identifying a user at 601. In multi-user embodiments, a keypad entry, bar code reader, RFID reader, voice recognition system or any other method of identifying a user is employed. In single user embodiments, this occurs when the user initiates exercise and the system identifies that a user is present. The method continues by retrieving past personal training information for the user at 602. This information comprises the force versus displacement measurement values recording in the initial workout session and any subsequent sessions for a particular user. The information is used in tailoring the exercise apparatus to the user so that full displacement of the exercise interface coincides with the physical size of the user. In addition, the information is used to set the proper resistance force level per unit of distance during displacement of the exercise interface. Information related to another user may be utilized in adapting the algorithm used for exercised based on historical performance and improvements observed in other users. In one or more embodiments of the invention, the past performance data may be associated with a user that has similar physical characteristics, age, weight, body fat and/or exercise goals. Loading an exercise program for the user from a computer occurs at 603. The exercise program utilizes the past personal training information to set the proper ratios for the user based on the user’s historical performance on the apparatus and based on the exercise goal of the user, e.g., strength, endurance, fitness maintenance or injury recovery for example. Again, the particular user’s past performance data and/or other user’s performance data may be utilized in choosing, altering or adapting the algorithm or exercise program utilized for the particular user. Accepting a user force imparted on an exercise interface when a user performs muscular exercise of a body part occurs at 604. At this point the exercise interface begins to displace since a force is acting upon it. Monitoring a position signal with a position sensor associated with the exercise interface at a position sensor sample rate occurs at 605. By monitoring the position signal at a given rate, the position of the exercise interface is determined for subsequent processing by the exercise program. Recording the position signal is performed at 606. Monitoring a force signal associated with the exercise interface at a force sensor sample rate occurs at 607. Recording the force signal is performed at 608 so that the force versus displacement measurements can be processed by the exercise program. Controlling a motor through use of a motor controller is performed at 609 wherein the motor is coupled with the exercise interface to counteract the user force with a resistance force. Adapting a ratio of a force versus displacement graph associated with said exercise program is performed at 610 wherein the force versus displacement graph is specific to the user and is in accordance with said exercise program that the user has selected. The adapting step utilizes present and past personal training information comprising position and force signals to adapt the ratio of resistance force with respect to the baseline measurement of force versus displacement for the user. The adapting step may for example reduce the ratio for a subsequent repetition to allow the user to complete a desired number of repetitions or to complete the repetitions in a desired time period. Displaying a rest period calculated by the exercise program optionally occurs at 611. The rest period may be displayed on a screen associated with the exercise apparatus or also be provided to the user via email, text messaging, on a web page or using any other method.

The rest period between sets may be displayed locally while the rest period between workouts may be sent to the user electronically in one embodiment of the invention for example and may utilize the present personal training information and the past personal training information to calculate when a user will be ready to exert force again. Prompting the user to initiate a subsequent effort occurs at 612 and may comprise local beeps for prompts that occur between sets or emails or other electronic communication for subsequent workouts.

[0050] While the invention herein disclosed has been described by means of specific embodiments and applications thereof, numerous modifications and variations could be made thereto by those skilled in the art without departing from the scope of the invention set forth in the claims.

What is claimed is:
1. A method for providing programmable adaptive resistance in an exercise apparatus comprising:
   identifying a user;
   retrieving past personal training information for said user;
loading an exercise program for said user from a computer;
accepting a user force imparted on an exercise interface when a user performs muscular exercise of a body part;
monitoring a position signal with a position sensor associated with said exercise interface at a position sensor sample rate;
recording said position signal comprising at least one position signal sample associated with said exercise interface through a displacement;
monitoring a force signal associated with said exercise interface at a force sensor sample rate;
recording said force signal comprising at least one force signal sample associated with said exercise interface through said displacement;
controlling a motor through use of a motor controller wherein said motor is coupled with said exercise interface to counteract said user force with a resistance force; and,
adapting a ratio of a force versus displacement graph associated with said exercise program to stress a muscle wherein said force versus displacement graph is specific to said user and in accordance with said exercise program and wherein said adapting utilizes present personal training information and said past personal training information wherein said present personal training information comprises said position signal and said force signal and said past personal training information comprises a past recording of said position signal and a past recording of said force signal.
2. The method of claim 1 wherein said adapting further comprises:
retrieving past personal training information for at least one other user; and,
altering said ratio of force versus displacement graph associated with said exercise program based on said at least one other user.
3. The method of claim 1 further comprising:
displaying a rest period calculated by said exercise program utilizing said present personal training information and said past personal training information.
4. The method of claim 1 further comprising:
prompting said user to initiate a subsequent effort.
5. The method of claim 1 further comprising:
measuring a maximum effort for a fixed time period at a constant velocity to generate an initial force versus displacement curve; and,
integrating said force signal over time to generate a baseline strength level.
6. The method of claim 1 further wherein said adapting comprises reducing said force by reducing said ratio as said user tires.
7. The method of claim 1 further comprising:
summing all integrals of said force signal over time for said each repetition performed at rate set at an initial workout session to generate a baseline endurance level.
8. The method of claim 1 further comprising:
calculating a number of repetitions at which a final integral of force versus time for a final repetition is less than an initial integral of force versus time for an initial repetition.
9. The method of claim 1 further comprising:
setting a force versus displacement ratio to allow for a desired number of repetitions.
10. The method of claim 7 further comprising:
calculating a current endurance level by averaging each end point percentage of said baseline endurance level actually achieved and storing a number of achieved repetitions and ratios of each said achieved repetition.
11. The method of claim 1 further comprising:
summing all integrals of said force signal over time for said each repetition to generate a current endurance sum.
12. The method of claim 1 further comprising:
increasing a force versus displacement ratio to provide overtraining.
13. The method of claim 10 further comprising:
increasing said rest period when said current endurance level decreases.
14. The method of claim 1 further comprising:
providing said user with an eating regime.
15. The method of claim 1 wherein said exercise program comprises strength training, endurance training, fitness maintenance or injury recovery.
16. The method of claim 1 further comprising:
providing said user with a progress report via printout, email, text message or web page.
17. The method of claim 1
marketing a product to said user based on said exercise program.
18. The method of claim 1
rewarding a user based on a current performance or a performance increase over time.
19. A programmable adaptive resistance exercise apparatus comprising:
a motor;
a motor controller coupled with said motor;
an exercise interface coupled with said motor wherein said exercise interface is configured to accept a user force exerted by a user when said user performs muscular exercise as said user moves said exercise interface against a force produced by said motor;
a force sensor configured to measure said force applied to said exercise interface, wherein said force sensor is configured to produce a force signal;
a position sensor configured to measure a position of said exercise interface, wherein said position sensor is configured to produce a position signal;
a digital input device; and,
a computer coupled with said motor controller, said force sensor, said position sensor and said digital input device wherein said computer is configured to identify
said user using said digital input device, retrieve and store personal training information, calculate an exercise program based on a user preference, obtain a force signal and said position signal and interface with said motor controller to adaptively control said force produced by said electric motor through utilization of present and past personal training information.

20. The system of claim 19 wherein said computer is further configured to:

retrieve past personal training information for at least one other user; and,

alter said exercise program based on said at least one other user.

21. The system of claim 19 wherein said computer is configured to display a rest period.

22. The system of claim 19 wherein said computer is configured to alert said user to begin a subsequent workout.

23. The system of claim 19 wherein said motor is directly coupled with said exercise interface and wherein said motor is a DC torque motor or AC vector motor.

24. The system of claim 19 further comprising:

a drum coupled with said motor and further coupled with said exercise interface and wherein said drum is coupled with said exercise interface using a belt, cable or chain.

25. The system of claim 19 wherein said digital input device comprises depressible keys or a voice recognition system or an RFID reader configured to read a gym card configured with an RFID component or a bar code reader configured to read a gym card configured with a bar code.