(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 April 2006 (27.04.2006)

PCT

(10) International Publication Number
WO 2006/042415 A1

(51) International Patent Classification:
A61B 5/22 (2006.01)

(21) International Application Number:
PCT/CA2005/001620

(22) International Filing Date: 24 October 2005 (24.10.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/620,679 22 October 2004 (22.10.2004) US
60/680,474 13 May 2005 (13.05.2005) US

(71) Applicant *(for all designated States except US)*: **INCORP VENTURES INC.** [CA/CA]; 2425 Matheson Blvd. East, 8th Floor, Mississauga, Ontario L4W 5K4 (CA).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **HANOUN, Reed I.** [CA/CA]; 5368 Vail Court, Mississauga, Ontario L5M 6G9 (CA).

(74) Agents: **BEHMANN, Curtis B.** et al.; BORDEN LADNER GERVAIS LLP, World Exchange Plaza, 100 Queen Street, Suite 1100, Ottawa, Ontario K1P 1J9 (CA).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

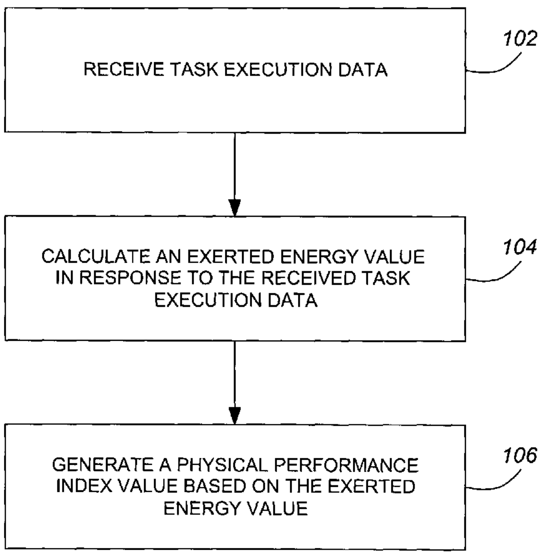
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report*

[Continued on next page]

(54) Title: METHOD OF CHARACTERIZING PHYSICAL PERFORMANCE



(57) Abstract: A method of measuring physical workload for a task is provided. After receiving task execution data, an exerted energy value is calculated in response to the received task execution data. A physical performance index value is then generated based the exerted energy value. The exerted energy value can be calculated based on a calculated work value, which itself is based on the received task execution data. A physical performace device, such an exercise machine, can be characterized based on the performance index value. The method can include compling a physical performance device profile including the physical performance index value, and optionally transmitting the profile to a storage means. The method can also include identifiying a functional muscle group associated with the device. The measured physical workload can be a measured value of user performance, which can be compared to a target value to determine a user's physical performance.

WO 2006/042415 A1

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD OF CHARACTERIZING PHYSICAL PERFORMANCE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority of United States Provisional Patent Application Serial No. 60/620,679 filed October 22, 2004 entitled "Automated Human Performance System", as well as United States Provisional Patent Application Serial No. 60/680,474 filed May 12, 2005 entitled "Mytrack System", both of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to human performance measurement. More particularly, the present invention relates to a method of characterizing and calculating physical performance.

BACKGROUND OF THE INVENTION

As the baby boom market continues to age and obesity in all age groups continues to take center stage, health delivery services, in particular the exercise and wellness sectors are being called upon to adapt to the unique and sophisticated needs of the market. Clearly, the trend in today's market is to maximize the benefits and efficiency of physical activity without spending countless hours at a gym. People are realizing that ultimate health should combine nutrition and lifestyle with a balanced exercise program for real, lasting results and improved physical well being, whether at work, home or play. Companies too are feeling the squeeze from employee obesity, workplace injuries, absenteeism and the overall state of ill health in the workplace.

Of the 100 million individuals in the United States that participate in exercise programs, over 80% fail to maintain a balanced long-term health program. They quickly become overwhelmed with the complexities of balancing dietary intake, nutrition, exercise activity and lifestyle, and thus fail to devote the necessary time and discipline needed to impact true and lasting health. Time is a very precious commodity today; as a result, people can be unwilling to devote the necessary time to the manual day-to-day management of a comprehensive health program. In most cases, individuals are left to their own motivation and planning in the development and execution of their health and exercise programs. Some facilities provide limited guidance once members join, but quickly dissolve that one-on-one personal management service.

Equipment sold today lacks the technology, objectivity, science and tracking to successfully associate the physical functions of exercise, the physiological outcomes of the body with the effectiveness of a well-balanced nutritional intake program. This leaves the user to experiment without any real objective, benchmark or tracked outcome, making it extremely difficult for users to reach and maintain optimum health.

When a person exercises, either at home or in a fitness club, they usually have some goal in mind, such as getting fitter, staying fit, increasing strength, loosing weight etc. To get the most benefit from exercise it is important that the user knows exactly what goal they have been set and how they are performing, both on an immediate real-time basis and over time. This leaves the exerciser with a number of key questions: How well have I done? How much energy did I exert and how many Calories did I burn? Did I perform well against my target or exercise program? What was my target? Did I do better this time, compared to last time or my historical data? Am I improving and progressing my fitness level? Exactly how fit am I?

To set goals and track fitness can require measuring how much energy a person has exerted during exercise, i.e. Calories, power and workload the muscles are performing while continuously monitoring heart rate against a training zone. The current method of establishing a person's absolute maximum performance on any given piece of exercise equipment is to get that person to exercise to exhaustion while measuring the parameters of interest: heart rate, oxygen consumption, weight lifted etc. This data provides an individual's maximum performance at that point in time i.e. the individual's 100% output or ability. However this may be only 60% of the standard for that individual's age or sex. Such standards (high, average, poor, etc) are available for aerobic fitness (VO2max) as established on a treadmill, bike, or step test and some physical performance tests.

This method, for most people, is impractical, since as you are improving in fitness, you would be required to re-take the tests to track any change in fitness level. While a person may feel that they have exercised well, and are improving, without some absolute measure of performance it is difficult to know for sure. Therefore a simpler, more practical way is required that measures performance against goals as the person is exercising, tracks fitness and progression and can be tailored to each individual.

There are known approaches in which a counter is used to measure revolutions of a weight stack. A display portion of the system allows the user to log in using a PIN, providing exercise execution information such as seat and weight settings, target sets and reps, and rep counts. A computer can be provided in a fitness club, at which a user can observe the statistics based on the user's workout. Exercise machines are networked into a central database, and the system can be accessed on a workout floor, a staff computer workstation, or via the Internet. Staff can create workout templates and performance monitoring tools, and send members customized messages via the system. The performance monitoring allows staff to identify in real-time which members need assistance and provides targeted feedback to the staff. Progress reports and graphs are available to users. Non-machine activities such as jogging, swimming and fitness classes can be logged in to the system. Reports to management can also be generated that detail both member and staff demographic data.

While such known approaches provide computer-based solutions for fitness training, those solutions are essentially electronic versions of a performance card on which measured repetition and set data is stored and possibly compared to a target value. The feedback provided is minimal, and only provides information relating to targets for sets and repetitions, not in terms of overall health targets.

It is, therefore, desirable to provide a method of calculating physical performance, which can be used in association with a human performance system, that overcomes some of the drawbacks of existing solutions.

SUMMARY OF THE INVENTION

It is an object of the present invention to obviate or mitigate at least one disadvantage of previous health delivery services and health management systems.

Embodiments of the present invention utilize proprietary technologies and advanced scientific analysis to deliver a complete automated health management solution deployable to a plurality of health verticals.

Embodiments of the present invention will preferably provide users with automated, personalized health management while tracking, assisting, motivating and encouraging them to achieve the maximum results in less time. This automated technology and process can encompass many different areas, such as diet, nutrition, physical activity, and lifestyle.

In an aspect of the invention, there is provided a method of measuring physical workload for a task, including the following steps: receiving task execution data; calculating an exerted energy value in response to the received task execution data; and generating a physical performance index value based on the exerted energy value.

The step of calculating the exerted energy value can include calculating a work value based on the received task execution data, and determining the exerted energy value based on the calculated work value. The received task execution data can include task baseline data or user performance data. The method can further include, prior to the step of receiving, the step of measuring the task execution data.

The step of generating the physical performance index value based on the exerted energy value can include multiplying the exerted energy by a machine constant. The machine constant can be determined based on: a ratio of energy exerted in performing the task and a ratio of time spent performing the task; a ratio of energy exerted in performing the task and a machine maximum energy value; or a ratio of cylinder force constants.

The physical performance index value can include a measure of exercise intensity. The method can further include: displaying a physical performance indicator to a user, the physical performance indicator being determined based on the physical performance index value; determining a user's physical performance based on a comparison of the physical performance index value with a baseline value in a pre-defined profile; determining a user's physical suitability to perform a second task based on a comparison between the physical performance index and a second task baseline value; or determining a degree of a user's physical function based on a percentage difference between the physical performance index value and a physical function baseline value.

In another aspect, the present invention provides a method of characterizing a physical performance device, including the following steps: receiving task execution data; calculating an exerted energy value in response to the received task execution data; generating a physical performance index value based on the exerted energy value; and compiling or generating a physical performance device profile including the physical performance index value.

The step of calculating the exerted energy value can include calculating a work value based on the received task execution data, and determining the exerted energy value based on the calculated work value.

The method can further include one or more of the following steps: identifying a functional muscle group associated with the device; determining a machine inefficiency based on a comparison of a measured PI value for the device and a standard device type PI value; prior to the step of receiving, measuring task execution data; and transmitting the physical performance device profile to a storage means.

In other aspect, the present invention provides a computer-readable medium including statements and instructions which, when executed by a computer, cause the computer to perform the steps of the method of measuring physical workload for a task, as described above.

In a further aspect, the present invention provides a computer-readable medium including statements and instructions which, when executed by a computer, cause the computer to perform the steps of the method of characterizing a physical performance device, as described above.

In a yet further aspect, the present invention provides a computer readable medium comprising a data structure, the data structure including a physical performance index value generated by the method of measuring physical workload for a task, as described above.

In a still further aspect, the present invention provides a computer readable medium comprising a data structure, the data structure including a physical performance device profile generated by the method of characterizing a physical performance device, as described above.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Fig. 1 is a flowchart illustrating a method according to an embodiment of the present invention;

Figs. 2A-2C illustrate three types of hydraulic exercise machines; and

Fig. 3 is a block and flow diagram of a system with which a method of embodiment of the present invention can be used.

DETAILED DESCRIPTION

Generally, the present invention provides a method of measuring physical workload for a task. After receiving task execution data, an exerted energy value is calculated in response to the received task execution data. A physical performance index value is then generated based on the exerted energy value. The exerted energy value can be calculated based on a calculated work value, which itself is based on the received task execution data. A physical performance device, such as an exercise machine, can be characterized based on the performance index value. The method can include compiling a physical performance device profile including the physical performance index value, and optionally transmitting the profile to a storage means. The method can also include identifying a functional muscle group associated with the device. The measured physical workload can be a measured value of user performance, which can be compared to a target value to determine a user's physical performance.

While some known systems and methods can count repetitions and sets, and possibly compare the data with a baseline level, such systems do not provide any indication of a level of exertion or human performance for a particular user when performing the repetitions and sets observed. There is no analysis, data management, or feedback in known systems. The present invention provides additional analysis tools, and provides information on energy exerted, calories burned, and many other useful parameters not provided by the known systems. It can be described as relating to automated monitoring of exercise equipment and the calculation or estimation of an individual energy output during the use of this equipment. In other words, known systems provide *tracking* of fitness data while the present invention provides *total management* of fitness data. Though embodiments will be described in relation to fitness and exercise machines, the present invention can be used to measure physical performance on any machine or device requiring physical exertion, and compare a measured value with a performance target.

An embodiment of the present invention measures a person's physical exertion via a machine on which the exertion is being made, in such a way that it can be compared with a performance target. The methods described herein are advantageously employed in the context of a computerized physical performance measurement system. An example of such a system is described in the inventor's commonly-assigned PCT Application No. ______________________ entitled "System For Measuring Physical Performance And For Providing Interactive Feedback" filed of even date herewith, which is incorporated herein by reference. Following a description of some embodiments of the present invention, a description of such a system will be provided below, in order to provide a suitable context for the application of methods and other aspects of embodiments of the present invention.

Performance Index (PI)

Performance Index (PI) is a global measure that establishes a physical performance level in relation to, or for, a piece of exercise equipment. The PI is a measure against which a person can set targets. It can also represent a person's overall physical performance and body efficiency during exercise. The PI measure can be applied to any form of exercise, from aerobics to gym equipment and specialist training. PI is a unique measure according to an embodiment of the present invention, which is based on the energy a person uses while exercising.

Because different exercises and exercise machines will exercise the body in different ways and use different amounts of energy, it is advantageous to characterize each machine with respect to the PI scale, so that an accurate measure of PI can be made. In a presently preferred embodiment, PI is based on a linear scale from zero to about 1000, with the premise that an average person with a high level of fitness will perform at a PI of about 1000.

The use of PI as a universal standard means that it can be applied to any type of exercise equipment. Exercise routines on a weight stack, exercise bike, rowing machine, treadmill etc. can all be defined and related to a standard PI value, e.g. PI=1000. By installing an electronic controller on an exercise machine and applying the correct type of sensor, energy can be measured and thus performance calculated.

Suppose a user is aiming for a target PI of 100. If that user employs two completely different and independent products and product types as part of an exercise program, including the method and resistance type, the end result is that the user's PI is constant. If you are aiming for a PI of 100, you are aiming of a PI of 100 on any machine that has been classified according to this system. It is not necessary to have different measures or classifications for each different machine or even each different type of machine, since the PI measure can be applied to any type of machine. As such, PI can be described as a standardized measure of energy, or of exerted energy.

Measuring PI

In order for PI to be used as a standard measure against which user performance can be gauged or ranked, there needs to be a generic way of calculating a PI value for a given exercise machine, or physical performance task/job. Having a consistent way of calculating a PI value is one reason why it can be used as a standard measure. This method can be used either for determining a baseline PI value to characterize a physical exertion device, or for determining an actual PI value while a user is exercising.

Fig. 1 illustrates a method of calculating a physical performance value. While the preferred physical performance value to be calculated is PI, this method can be used to determine any measure of intensity of physical performance or exertion. Step **102** shows a first step of receiving task execution data. The received task execution data can be task baseline data that was previously measured and is stored in a memory. In another case, the received execution data can be measured data relating to a characterization of a task. In the case of determining in real-time a user's current PI value, the task execution data can be user performance data. The method can additionally include the step of measuring task execution data, such as measuring user performance data. This additional step is preferably performed before step **102**.

Step **104** in **Fig. 1** shows a second step of calculating an exerted energy value associated with a task in response to the received task execution data. Step **104** can include a sub-step of calculating a work value and determining the exerted energy value based on the calculated work value. Known mathematical relationships between work and energy for each particular job/task are used in order to determine the exerted energy value based on the calculated work value. Step **106** shows a third step of determining, or generating or calculating, a performance index value based on the exerted energy value. The method can also include a further step of displaying a physical performance indicator to a user, the physical performance indicator being determined based on the physical performance index value.

PI values are scaled versions of an energy value, either a measured exerted energy value or a target exerted energy value. The target exerted energy value can alternatively be referred to as a measure of required exerted energy. A machine maximum energy value is determined for an exercise machine. This determination is based on the maximum amount of energy that would be required to operate that machine at full capacity for a given period of time. A maximum PI value of 1000 is correlated to the machine maximum energy value. PI values between 0 and 1000 are then associated with corresponding energy values between zero and the machine maximum energy value, based on an appropriate calculation, preferably in relation to a linear scale. A PI value table can then be generated based on those associations, and stored on a computer readable medium. Therefore, when a user is doing an exercise on a machine, an exerted energy value can be calculated based on received user performance data, and a measured PI value can be calculated based on a comparison of the calculated exerted energy value with values in a performance index table for the machine.

For characterizing a physical performance device, such as an exercise machine, the performance index value is determined by multiplying the exerted energy value by a scaling factor. The scaling factor can be a machine constant for the exercise machine being used. The machine constant can be determined based on a relationship between a ratio of energy performed and a ratio of time spent. For example, for a hydraulic cylinder, the machine constant is determined based on a comparison between a ratio of energy performed in forward and reverse motion of the cylinder, and a ratio of time spent on the forward and reverse motion of the cylinder. This method can alternatively be implemented as, or described as, a method of estimating energy expended, and tracking/integrating that over time. Obviously, the machine constant is different for each different machine.

Example PI Determinations for Different Machines

In terms of the implementation of the present invention with different types of machines, different sensors are used for each different type of machine, or product type. Different sets of data are collected from each machine type. The sets of data are interpreted differently for each product type. However, a common end result is always achieved, namely a qualification of performance index.

For a weight stack, the determination of PI includes considering the amount of weight being lifted in a given period of time over a given distance. From this raw data, the distance and the time and load values are used to calculate velocity, acceleration, energy and every other mathematical calculation that is necessary. All of that calculated data is correlated to the scale of human performance index.

Spinning has taken traditional bikes and turned them into a means for complete exercise programs. The next evolution in programs is feedback and automation being incorporated into those programs. To use an embodiment of the present invention with spinning applications, a pressure foil mechanism is used and is mounted between the plastic of the brake pad and the felt of the brake pad. As a result, the sensor measures the pressure on the surface area of the bike's brake pad. The more the brake is squeezed, the more pressure will be sensed. At the same time, the system includes an optical sensor that detects wheel position. Therefore, the system can measure how hard the brake pad is being squeezed and how fast the wheel is spinning; on the basis of those measurements, position, resistance, and heat generated can be determined. In relation to time and those other factors, the energy being exerted can be measured. Once the energy value is obtained, this can be related to the PI scale. On the basis common PI number, the system can provide indications of the settings to be used on the particular machine, such as putting a spinning machine on setting number 9.

For hydraulic machines, a similar PI determination is made. However, work in this case is not determined with respect to a load being lifted. In such a case, the system looks at sensor data in terms of position versus time based on the characteristics of the piston, such as the characteristics of the orifice and the viscosity of the fluid or liquid and the amount of time it would take for a person to move a particular amount of fluid from one chamber to the other. In an exemplary characterization or calibration method, a piston is taken and characterized based on these parameters. The piston is then tested on the fixtures and devices of a testing system for the present invention so that it can be characterized, that is to indicate the optimal efficiency of the piston. A separate characterization machine is preferably used for such purposes. A resulting table is provided based on the characterization testing of the piston. The table can be graphed and once a full matrix is obtained, that matrix can be included in software which is part of a system using the present invention. These features provides the ability to characterize or calibrate a piston and any number of different pistons, as well as to create a unique profile for each such piston and to put that profile directly into software tables. Once the piston has been characterized, the rest of the logic can be applied in terms of work, velocity, time, piston setting and other parameters in order to equate that to PI as well.

Machine Inefficiencies and Muscle Group Identification

One aspect of the present invention can be described as a method of characterizing a physical performance device, including the following steps: receiving task execution data; calculating an exerted energy value in response to the received task execution data; generating a physical performance index value based on the exerted energy value; and compiling a physical performance device profile including the physical performance index value.

Aside from a machine's PI value, there are other parameters that can be included in a machine characterization, or a machine profile.

Inefficiencies of a particular machine can be taken into account. A machine inefficiency can be determined based on a comparison of a measured PI value for the device and a standard device type PI value, which can be a standard PI value for the machine type, or machine class. A determination can be made as to how much energy (or additional physical energy) is being exerted by a user as a result of the calculated machine inefficiency. A relationship can also be made between the human energy exerted and the human performance index scale. This analysis is preferably done for each available machine in a particular machine type or class. This can be part of the machine characterization, or appraisal or calibration, process. Therefore, a machine profile preferably includes a machine inefficiency parameter, the scale of which is preferably suitable to account for machine performance that is either better or worse than an expected value. A report rendered to a user can preferably account for such machine inefficiencies when analyzing the user's performance data.

A machine characterization also preferably includes an indication of the functional muscle group(s) that the machine exercises. This can be based on a step of identifying a functional muscle group associated with the device. A functional muscle group parameter can include an indication of whether the machine primarily or secondarily works particular muscle groups, and what the ratio or percentage is. Machines can then be classified based on the functional muscle groups that are worked by the machines. Once the work requirement is known, as well as the energy distribution by muscle ratios, and once this is related to the indexing of PI, this results in a system as described above, including feedback relating to PI. For example, a report rendered to a user can preferably generate muscle-group based reports based on user performance data at each machine that works that muscle group, taking into account the percentage of work for each muscle group at each machine.

Based on known machine information related to muscle groups being exercised by that machine, a method according to an embodiment of the present invention can include a step of calculating a PI value for each muscle group. In the case of determining a target value, the method can include a step of calculating a PI capacity, or maximum PI value, for each muscle group.

Other Industrial Applications

In addition to the examples described above in relation to the exercise/fitness industry, there are many other applications for embodiments of the present invention.

A method according to an embodiment of the present invention can determine a user's physical performance, and compare it with a baseline value, such as a job value. The job value can be calculated by determining the total job energy required. For example, in the case of the job of lifting a box, the total job energy required can be calculated based on a measured weight of the box, the height that the box must be lifted, and any other value. Based on a knowledge of the muscles required to perform the job, a job profile can be generated based on a proportionate distribution of the total job energy. The method can provide an identification of an area of shortfall by comparing a user's measured PI value with a job PI value. Since muscle-group level information on the target and the measured values is available, the method can provide an identification of the particular muscle group, or part of the body, which is the cause of the shortfall. In that way, the method can also provide an improvement recommendation based on the identified area of shortfall.

A computer can store a plurality of predefined profiles. Those predefined profiles can include parameters, such as a PI index, used to classify or appraise a user by age, gender and occupation. A user's measured physical performance can be compared to a pre-defined profile for that type of individual. A system can be used to assign a muscle specific PI Index and a overall global body PI Index to each user. The user's measured PI value(s) can be used in the following contexts:

Work Related Job Matching:

a. Matching employees to the jobs they are expected to perform at work.

b. Objectively identifying injury probability based on collected data from various workouts by comparing observed performance to job profiles.

c. Modifying, or identifying potential modifications, to the ergonomics or physical demands of a job to closer match the physical function of an individual performing such a job.

d. Conditioning, or identifying potential training or conditioning programs, to condition the individual to better match the required physical demands of their job.

Rehabilitation and Medical Application:

a. Tracking the physical function and improvements of people in therapy.

b. Matching the physical function of people in rehab to identify return to work readiness.

c. Evaluating the effectiveness of therapy based on injury type and physical disability, impairment.

d. Used by insurance companies to establish the degree of functional loss resulting from injury be objectively establishing the amount of PI loss.

Sports Teams:

a. Matching sports players to pre-defined ideal profiles based on played position and actual sport.

b. Determining and track individual muscle behaviours prior to the onset of physical injury.

The above-described scenarios can be described as an extension of a previously-described method according to an embodiment of the present invention further comprising the step of determining a user's physical performance based on a comparison of the physical performance index value with a baseline value in a pre-defined profile. For example, this can include determining a user's physical suitability to perform a second task based on a comparison between the physical performance index and a second task baseline value. This can also include determining a degree of a user's physical function based on a percentage difference between the physical performance index value and a physical function baseline value. In any of these cases, the method can include displaying, or otherwise providing, a physical performance indicator to a user, the physical performance indicator being determined based on the physical performance index value.

Example of PI and Equipment Characterization in an Exercise Context

During an exercise, an electronic controller can use a sensor to measure parameters of an exercise machine's resistive element. For example, for a hydraulic machine, the sensor can measure cylinder velocity. Knowing the cylinder setting, it is possible to calculate the force being exerted, and over time the amount of energy being used. Each piece of exercise equipment requires a machine constant setting that will be used to convert energy to PI. Based on the type of exercise to be performed e.g. weight loss program, strength program etc. a standard setup is established that consists of the exercise duration, number of strokes and the cylinder resistance setting and Calorie burn. This then becomes the standard and represents a performance level of PI=1000.

The present invention can store this data in a database of physical performance measurement device profiles, or exercise machine profiles. In an embodiment, a storage means, or central database, of a computerized exercise system can comprise the database of exercise machine profiles. For a hydraulic machine, the exercise machine profile can include some or all the following information: manufacturer model; type; and cylinder used. This system also allows individual cylinder settings to be used on those machines that are fitted with easy adjustment mechanisms.

The characterization of equipment can be done using a computer based software program that can be attached to the equipment to measure and determine the various machine parameters. An overview of this process is given.

Once the machine is calibrated, this data can be used by a Kiosk to calculate the various information tables required by an Exercise Controller (EC), attached to a piece of exercise equipment. This data is based on the exercise profile, either automatically determined or setup by the user.

After completion of the exercise, the data that the EC sends back to the Kiosk requires analysis to give user feedback on performance. For each piece of exercise equipment that has an Exercise Controller attached, a first step is to determine its PI rating where an Average Person will score a PI of 1000. This can be done by setting: Time duration of Exercise T_{AP}; Number or Reps at full stroke N_{AP}; and Machine Resistance Setting C_{AP}.

These numbers can initially be set from experience, but can later be adjusted as exercise data is obtained and a better understanding of PI and AP is made. From these numbers, and knowing the characteristics of the machine, we can determine the energy used for that exercise and calculate an equipment constant (K) that will relate this amount of energy to PI=1000.

For a particular user and exercise, the Kiosk will set the target PI, exercise duration and number of reps. From this data, the energy the user needs to expend to achieve this exercise level can be calculated. This is the 100% level for PI. This energy level can then be scaled from 0 to 100%. A user can put in more energy, to exceed their target, however warning levels need to be set to indicate too much effort is being done and to warn against possible injury. Therefore levels of 125% and 150% are also set.

Example of PI and Equipment Characterization for a Hydraulic Device

A detailed explanation will now be provided with respect to calculations of PI for hydraulic exercise equipment. Similar calculations for other types of equipment will be evident to one of ordinary skill in the art.

Each cylinder has a particular characteristic that relates piston velocity to the force required to move it. This can be measured on a dynamometer and approximated to a polynomial equation of the form:

$$F = av^2 + bv + c$$

where f is the force and v the velocity. If cylinder is configured where the force is different in the forward and reverse directions, two force factors are required.

Over the low velocity range that the cylinder is used, with a maximum of 10mm/sec. this can be approximated to a straight line, therefore the equation becomes:

$$F=fv$$

where f=Force factor (Ns/mm) for a particular cylinder direction and setting, F=Cylinder Force (N), and v=velocity (mm/s).

In addition each piston may have up to 10 settings through the adjustment of the bleed valve (some cylinders will have less, therefore the table may not be fully populated). Each of these bleed valve or "hardness" settings has a different f value. Therefore a database of cylinder type, hardness setting and the forward and reverse force factor value is required.

When in use on each machine, the equations v=d/t and F=fv can be used to relate all these variables to get energy as follows;

$$E = Fd = f(d^2/t)$$

where d=distance (mm), t=time (s) and E=Energy (mJ) required to move the cylinder over distance d in time t.

An exemplary table for a cylinder with 8 settings is shown in **Table 1** below:

Parameter	Value
Manufacturer	Rancho
Model	RS99120

Valve Setting	Value (fwd)	Value (rev)
1	1.25	0.65
2	1.87	0.87
3	2.10	0.91
4	2.65	1.23
5	3.60	1.54
6	3.80	1.76
7	4.20	1.87
8	4.56	2.34

Table 1

Exercise machines with hydraulic cylinders fall into a number of different categories based on how the cylinders are configured. Categorizing the machine in this way enables one equation to be used for the energy calculations. **Figs. 2A-2C** illustrate three types of hydraulic exercise machines.

The forward and reverse force factors for the machines can be calculated as follows:

Type 1: Single cylinder machine (shown in **Fig. 2A**)

$$f_{FWD}=CYL_{FWD}$$

$$f_{REV}=CYL_{REV}$$

Type 2: Dual cylinder machine with cylinders working in the same direction (shown in **Fig. 2B**)

$$f_{FWD}=CYL1_{FWD}+CYL2_{FWD}$$

$$f_{REV}=CYL1_{REV}+CYL2_{REV}$$

Type 3: Dual cylinder machine with opposing motion (shown in **Fig. 2C**)

$$f_{FWD}=CYL1_{FWD}+CYL2_{REV}$$

$$f_{REV}=CYL1_{REV}+CYL2_{FWD}$$

Other types of machines may become apparent in the future.

Therefore a database of exercise machines is required, that describes the Manufacturer, Model, Type and Cylinder used. This database can comprise machine profiles as discussed earlier. Also, a fitness club may set the cylinder hardness for each machine differently, therefore when a machine is selected, the cylinder setting is preferably also selected so that the force factors for the local club are known.

A distance measuring device is provided for use on the cylinder, since this has specific characteristics and may be non-linear. Some devices may not measure from zero, so the stroke minimum and stroke maximum can also be provided in the database.

Table 2 below represents an exemplary entry for a machine:

Parameter	**Value**
Manufacturer	ABC 123 Inc
Model	Tricep Bicep Pull
Type	2
Cylinder	Rancho RS99I18
f forward	1.26
f reverse	2.85
Stroke Min (cm)	10
Stroke Max (cm)	30
Sensor	GPSD12
Sensor Formula	6524.2*x**-0.8273

Table 2

The EC carries out a number of calculations to determine the Performance Index and Range of Motion. These values can be calculated by the Kiosk and sent to the EC in the form of data tables. A lookup table is used by the EC to display the range of motion on 9 LED's. The data sent to the EC can be the binary value that represents the reading from the distance sensor. Therefore the Kiosk can calculate these values into a table.

As an example the Sharp GPSD12 has a non-linear output that can be calculated using the values and equations below. Define the following parameters: L = Stroke Length; L_{MAX} = Stroke Maximum; L_{MIN} = Stroke Minimum; R = Stroke Resolution; and V = Sensor Voltage as a 10-bit resolution input. Taking into account that $L = L_{MAX} - L_{MIN}$, $R = L/9$.

To perform further determinations: Calculate cylinder position from L_{MIN} to L_{MAX}. in steps of R; Calculate Sensor Voltage using the formula for the sensor; and use the fact that $V = 6524.2x^{-0.8273}$. Results are shown in **Table 3** below.

LED	Cylinder Position (cm)	Sensor Voltage
1	10.00	1024
2	12.22	822
3	14.44	716
4	16.67	636
5	18.89	574
6	21.11	523
7	23.33	482
8	25.55	447
9	27.78	417

Table 3

Performance Index and PI Calculation

Once the PI is established, then the energy can be calculated and by using the above energy equation, the energy put into the machine by the user can be determined, by sensing the change in the cylinder distance over time. Because the EC measures cylinder position at regular intervals based on the processor clock time or ticks, it is possible for the Kiosk to calculate all this out and send to the EC a table that relates the PI% to a change in distance per clock tick. The energy calculation will depend on the machine type and take into account different cylinder constants for forward and reverse motion.

Once the force factors have been calculated as above, the PI can be calculated in the same way for all machine types. The following variables will be used in the discussion that follows: T= exercise time (sec); E= total energy to be expended (mJ); f_{FWD} = forward cylinder force factor (Ns/mm); f_{REV} = reverse cylinder force factor (Ns/mm); E_{FWD} = Energy to be used in forward motion (nil); E_{REV} = Energy to be used in reverse motion (ml); IER = instantaneous energy rate to be used in forward motion; t = Exercise controller clock time (msec); T_{fwd} = time of forward motion; T_{REV} = time for reverse motion; and f_r = force factor ratio.

The Energy is calculated from the machine constant. Since the number of forward and reverse strokes is the same, the energy needed for both forward and reverse motion can be calculated by factoring the energy by the ratio of the cylinder force constants as follows:

$$f_r = f_{FWD} / (f_{FWD} + f_{rev})$$

$$E_{FWD} = E \times f_r$$

$$E_{REV} = E - E_{FWD}$$

However because the energy needed to move the cylinder in each direction is different it is likely that the forward stroke will be longer in time that the reverse stroke. This is particularly true if the return stroke offers little or no resistance. Assuming that the ratio of the time for the forward and reverse strokes is the same ratio as the force factors, then the time in forward motion and the time in reverse motion can be calculated as follows:

$$T_{FWD} = T \times fr$$

$$T_{REV} = T - T_{FWD}$$

Since the total exercise time and the clock tick are known, the Instantaneous Energy Rate (IER) can be calculated as:

$$IER = (E_{fwd} \times t) / (T_{fwd} \times 1000)$$

The IER is the same for both directions, since both E and T are factored the same. So when the lookup table of PI% is calculated, the distance to be travelled by the cylinder needs to reflect the fact that equal effort must be put in on both strokes, and on the easier stroke the velocity (and the distance travelled) must be higher. Using the forward and reverse cylinder force factor takes this into account as follows:

$$d_{fwd} = \sqrt{(IER/f_{fwd})}$$

$$d_{rev} = \sqrt{}IER / f_{rev}$$

A look-up table for the EC can now be generated. **Table 4** below shows an exemplary look-up table having 14 entries, with only the last column of data being sent (other data is put in for an example). The distance is scaled by 10,000 so that it is more easily understood by the EC.

	PI (%)	**IER (mi/Tick)**	**Forward Distance (cm)**	**Forward Scaled Distance (cm)**	**Reverse Distance (cm)**	**Reverse Scaled Distance (cm)**
1	8	4	0.0497	497	0.0255	255
2	16	8	0.0703	703	0.0510	510
3	24	12	0.0861	861	0.0165	765
4	32	16	0.0994	994	0.1020	1020
5	40	20	0.11	1112	0.1275	1275
6	48	24	0.124	1240	0.1530	1530
7	56	28	0.131	1310	0.1785	1785
8	64	32	0.141	1410	0.2040	2040

9	72	36	0.149	1490	0.2295	2295
10	80	40	0.157	1570	0.2550	2550
11	88	44	0.165	1650	0.2805	2805
12	100	50	0.176	1180	0.3188	3188
13	125	62.5	0.196	1960	0.3985	3985
14	150	75	0.215	2150	0.4782	4782

Table 4

In the above example the forward and reverse cylinder factors are different, therefore the table reflects this. In other words, the reverse force factor is less than the forward one and the cylinder must be moved a longer distance each clock tick (faster) to maintain the same energy.

One additional check should be done before sending this table to the EC. A typical A/D converter has a particular resolution. Consider the case where the resolution of the A/D converter is 10 bits or 1 in 1023. For a typical cylinder, the stroke may be 200mm, therefore the measurement accuracy will be +/-0.0196cm. If the lowest value in the table is less than this resolution, the EC will not be able to resolve the smaller movements and cannot calculate the PI%. Therefore the clock rate may need to be adjusted to a slower rate for calculating position.

Heart Rate

A heart rate table can be set by calculating the heart rate zones. A measured resting heart rate (HR_{rest}) and an estimate of the maximum heart rate (HR_{max}), preferably adjusted for age, can be used to define a personal heart rate training zone for aerobic activities. The formula for estimating HR_{max} is: 208 - O.7AGE in beats per minute.

An additional aid to determining the heart rate training zone is to calculate the Heart Rate Reserve (HRR), which takes into account the resting heart rate. The heart rate reserve method can be calculated as follows:

Subtract the resting heart rate (HR_{rest}) from the estimated maximal heart rate (HR_{max}) to get the heart rate reserve (HRR):

$$HRR = HR_{max} - HR_{rest}$$

e.g. for an individual aged 30 with a resting heart rate of 60 beats/minute:

$$HRR= 187-60= 127$$

The heart rate zone will depend on the overall fitness of the client, or user, and what type of exercise target they are going for. This will typically be based on a self-reported assessment of fitness from the client. The individual will have to make an educated guess as to where he/she fits on a relatively broad, three-tier classification, such as:

1.	Low Fitness/Beginner	50%-60%
2.	Intermediate	60%-80%
3.	Advanced	80%-90%

The heart rate analysis is done to indicate how much time the users heart was in each of the 3 zones. This can be done by looking at the HR for each stroke and the time for that stroke and then calculating a percentage.

The ROM% can be calculated by dividing the cylinder position at the end of each stroke by the maximum range of motion for the machine as defined in the machine setup data.

Energy

A calculation of the energy used on each stroke is done by using the same energy formula $E = Fd = f(d^2/t)$, except the values are per-stroke values, such as: d=distance moved for stroke(mm); t=time of stroke(s); and E=Energy (mJ) required to move the cylinder over distance d in time t. The value of f can be different for forward and reverse motion.

Performance Index

The PI on each stroke can be calculated by first calculating the energy rate, followed by a comparison to the IER already calculated as part of the exercise profile data.

The energy rate is the amount of energy used per clock tick and can be calculated by taking the energy from above and dividing by the number of clock ticks for that motion (or stroke time divided by clock rate). A percentage can then be taken between this number and the targeted IER first calculated. This is the percentage of the PI. The actual PI achieved on each stroke can then be calculated by taking the above percentage and multiplying by the target set in the exercise profile.

Fatigue and Variance

A measure of the person's fatigue over the exercise period can be determined by calculating the slope of the PI% though a linear regression. A negative slope indicates the person is fatiguing. A simple variance to indicate consistency between strokes can be calculated by looking at successive PI figures and subtracting. This can be expressed as a % to show variation.

Calories

Because energy is being measured, this can be converted to calories using the following formula:

$$C = E/4190$$

where E = measured energy (mJ), and C = Calories. It is possible to relate this value to the calories burned by the exerciser by applying the following factors: inefficiency in the machine mechanism; inefficiency in body movement; and body mass index.

System Implementation

As mentioned earlier, the methods described herein are advantageously employed in the context of a computerized physical performance measurement system. A description of such a system now will be provided, in order to provide a suitable context for the application of methods and other aspects of embodiments of the present invention.

Fig. 3 is a block and flow diagram of a computerized exercise system **200**. The system **200** includes an identification device **202** for each user, and a storage means **204** to store a plurality of user profiles and performance data. The identification device **202**, such as an RFID tag, can be a microchip device worn by the user on wrist or chest. It preferably integrates and communicates with an optional Heart Rate detection system. The identification device, or user identifier, **202** actuates, or activates, each exercise station's processor, in particular a data acquisition intelligence system. Alternatively, each user can have a unique personal identification number (PIN) to enter at each exercise station.

The storage means **204** can be implemented as a central database or databank, in which case it acts as the main system of data collection and data management. In a preferred embodiment, data stored in the storage means **204** is centrally accessible, even in the case where the storage means comprises a plurality of physical storage devices. This provides an option of distributed storage. The terms "central database" and "databank" in this description are used interchangeably with "storage means", and represent a means for storage of data, from which the data is centrally accessible.

Information can be collected and stored in the databank and managed by, or on behalf of, each user as needed. The databank can collect information from as many local PCs as deployed. The databank can contain, for example, the following information: historical workout results, exercise programs, human performance physical profiles, training activity, achieved results, dietary information and various predictive analysis and algorithms. Other information can additionally be included, such as exercise machine profiles. This databank can also contain proprietary, scientific and mathematical formulas for calculating the various performance intensity factors for each member.

The system **200** tracks individual performance of each user. Each user is preferably automatically identified as they commence use of an exercise device. The computer system can also recall a program that has been previously established for that user and appropriately adjust the visual or other output display of the system to allow the user to monitor his own progress and perform at a desired personal level. In this way, each piece of exercise equipment is effectively customized for the individual user and the system tracks the individual's performance.

Referring back to **Fig. 3**, a plurality of exercise machine modules **208** are each in communication with the central database **204** via a communications network **206** to receive a stored user profile from the central database. In this example, the communications network can be implemented as an Ethernet link. While only one exercise machine module **208** is shown in **Fig. 3** for simplicity of illustration, in practice the system **200** includes a plurality of exercise machine modules **208**, as will be described and illustrated later. Each of the exercise machine modules **208** includes: a sensor system, or physical performance detection system, **210**; and an electronic controller **212**.

The sensor system **210** preferably includes an exercise machine sensor, for coupling to an exercise machine, preferably to a resistance element thereof, to measure performance data. For example, the sensor system **210** can include a sensor, such as a load cell mounted onto an exercise station weight stack, to continuously measure the force used for each repetition for each exercise. The sensor system can also include an encoder or potentiometer to be mounted on the exercise station and used to measure distance moved for each repetition. By adding various sensors to exercise devices such as bikes, treadmills, weight lifting machines, the system of the present invention is able to measure, calculate and provide feedback to users based on their degree of effort and desired goals.

The electronic controller **212** is coupled to the sensor system **210**, to determine or calculate exercise intensity in response to the measured user performance data, to compare the calculated exercise intensity with the user profile; and to provide feedback to the user regarding exercise intensity based on a comparison of measured performance data and the stored user profile. The exercise controller **212** can alternatively be described as being coupled to the sensor system **210** to calculate exercise intensity in response to the measured user performance data, to determine an exercise intensity indication, or parameter, based on a comparison between the calculated exercise intensity and the user profile, and to provide the exercise intensity indication as feedback to the user.

The electronic controller **212** can include a user identification unit **214** to receive a user profile from a central database **204**. The user identification unit **214**, or data acquisition intelligence system, can read or otherwise receive a user identifier, such as from an identification device **202**, e.g. an RFID tag. As such, the system of the invention can be described as including an identification module to receive a user profile from a storage means in response to a received user identification. The electronic controller **212** can also include a processor **216**, in communication with the user identification unit **214** and with the sensor system **210** associated with the exercise machine, to calculate exercise intensity in response to received user performance data, and to determine an exercise intensity indication (such as PI) based on a comparison between the calculated exercise intensity and the user profile. The electronic controller **212** can also include a feedback module **218**, such as a display, in communication with the processor **216**, to provide the exercise intensity parameter to the user. In other words, this device includes the intelligence to identify and communicate to the feedback system, while measuring the physiological and physical function of the body.

In the processor **216**, a data acquisition intelligence system can be implemented as a card that tracks all performance data including force, distance, time, heart rate, etc. The processor **216** preferably includes a memory with firmware or software comprising sequences and instructions to determine exercise intensity and workload. The processor can control various LED lights on the feedback module **218**, which can be implemented as a digital feedback unit, or display unit. The processor **216** can also communicate data to a computer **220**. The computer **220** can be implemented as a central computer, or in a distributed manner where the functions of the computer can be considered as centrally controlled, or centrally available. The processor **216** can also track and communicate heart rate data.

Although the system **200** has particular application for retrofitting with existing equipment, it can also be used with (or alternatively integrated in) new equipment. Furthermore, although the system is described with respect to the addition of sensors to existing resistance elements on the exercise equipment, new resistance elements can be added which include the sensors as part thereof. Obviously, the retrofit application provides a cost advantage.

In an example of implementation, a user would wear a heart rate belt and scan an RFID tag, or user identifier **202**, in front of the electronic controller **212**. Based on the downloaded user profile, the electronic controller **212** downloads a unique set of data tables specifically designed for that user, and provides an indication based on the data tables of how much weight the user should be lifting. While the user is exercising, the electronic controller can show the user's range of motion for the muscles, calculate how much energy the user has exerted, and can count down the repetitions based on the number of repetitions that have already been done.

The processor **216** comprises the necessary intelligence to vary the prescribed programming to continuously challenge the user to perform at their unique maximum capability while ensuring safety. At the end of each exercise session, the electronic controller **212** preferably automatically sends all tracked and collected outcome data to the central computer **220** for immediate reporting.

Automatic update of goals based on performance

The system can include dynamic, or automatic, modification or updating of a goal or target based on measured performance results. The system can include a measurement module **234** for extracting measured user performance data from the storage means or central database **204** and for comparing the measured data with the stored target data. For example, the data in question can be a Performance Index (PI). If the measured data shows that the measured PI value meets a target PI value, the target PI value can be increased slightly so that the user is set to improve when coming for the next workout. The update or modification of the goal, or target, can be performed by an automatic goal update module **236**. The amount by which the goal, such as a PI value, is increased is determined by a stored progression index, which is preferably stored in a memory accessible by, or within, the automatic goal update module **236**. The progression index can be a percentage by which the PI value, or any other value, is increased if the user reaches a target, or is decreased if the user fails to reach the target. Although any suitable value can be used and modified by the user, a presently preferred progression index value is about 10%.

Besides providing automatic updating of goals, the system can also provide the user the ability to manually modify parameters of an exercise, such as: weight, repetitions, and target performance index for that particular exercise. This user modification can be performed a user-accessible profile edits module **238**, which can be accessed via a web management module **240**. The profile edits module, or training module, can include relevant information on exercise programs as developed and managed. It can include personal information on the user as well as desired goals and objectives. The section can include critical data forming the cornerstone of health management information. Access to the module can be provided to various users based on security privileges, as defined by the system or by the member. A global target, such as a global performance index, is then preferably automatically updated based on any manual user modification or change to specific exercise parameters. The global PI preferably cannot be changed directly by the user.

The web management module, or web site, **240** can preferably be the interface used to manage all information gathered from all the various systems and users. It can feature various user interfaces for members, personal trainers, physicians, and other professionals based on the assigned security privileges. From this main system, users can be prompted to and provided with the ability to manage, accept, and modify various health information gathered and tracked by the system.

Integration of caloric intake with exercise program

Known systems do not provide a way for a user to easily integrate dietary intake with an exercise program. The system can provide a caloric intake module **242**, which can include modules to receive and store information relating to diet and/or intake. Meal consumption and caloric intake information can thus be entered into the same system that tracks fitness. As a result, the user performance targets, or fitness targets, for the individual can be dynamically modified based on meal consumption. The modified profile based on the updated caloric intake can then be sent to the health club or the communication module system and the user profile is updated accordingly.

Therefore, tomorrow's workout can be customized based on food consumed today and the workout can even be customized within the same day, given that the updated information can be transferred almost immediately and the user profile will be updated accordingly. As a result, the fitness program can always ensure that the user is burning off more calories than are being taken in. The total caloric intake can preferably be updated on a periodic basis, such as at the end of each day, and can preferably be based on knowledge of the user's caloric burn rate. A caloric value database that interacts with the web module of the system of the present invention preferably includes caloric values relating to different types of food, which the user can select when entering the meal consumption, such as by a drop-down menu. That way, the user does not need to have knowledge of calories associated with particular food types and amounts.

From home or office, the user can connect to a website module and enter their dietary intake. Software in, or in communication with, the caloric intake module calculates the caloric impact on the overall training program and analyzes the impact on weight gain/weight loss based on tracked training proficiency. On subsequent workouts, the software utilizes this revised profile and only activates the LED light feedback system based on the new modified work intensity requirement. This cycle of objectively documenting intake and associating it to measured output will not only enhance user compliance, but substantially improve the ability for the user to achieve their fitness goals.

The software can provide predictive analysis on various weight gain and weight loss scenarios for 30 days, 90 days, 6 months, one year and longer, based on observed dietary intake and activity intensity. The software recommends changes to future dietary intake and training intensity. Having access to dietary intake information can allow the predictive engine to forecast both the short and long-term impact on the users physical condition and associated physical risks. The predictive engine can be implemented as a predictive profiles module **244**, as shown in **Fig. 3**.

The predictive profiles module, or prediction system module, can be used by the member to analyze and determine weight gain/ loss scenarios based on measured and observed outcomes. Various algorithms and scientific principles can be utilized in determining the validity and effectiveness of various exercise training programs and to make the necessary recommendations to the user for change. A key prediction component can be determined by the measure of physical activity in comparison to the desired goals and objectives of the training program. Based on such measurements, the system can advise the user of the anticipated time of progress to achieve the desired goals.

Fatigue & Variance

When exercising, a user typically experiences fatigue. However, known systems do not provide the user with any indication of whether the amount of fatigue being experienced is normal. There is similarly no indication of whether the user is being consistent with respect to energy expended during a workout. Inconsistency and unusual fatigue are signs that a user's exercise program is not suitable and needs to be changed. The system can provide the ability to dynamically modify a user-specific exercise program based on measured fatigue and/or variance.

A fatigue and variance module **246** is shown in **Fig. 3** as being in communication with the storage means **204**, and having access to the measured user performance data. While this module is shown as a single module, the two functions can be implemented separately. With respect to fatigue calculation, this can be determined in relation to the calculated energy per repetition and any variation there has been between energy per stroke by observing the slope of a line showing the energy expended. This shows whether the person is exerting more energy continuously or losing more energy continuously. In a normal healthy individual training at the full intensity, a strength loss rate of about 10 % is expected.

A coefficient of variance, which is a measure of consistency, illustrates how consistently the repetitions were performed. If energy is increasing or decreasing but the consistency is not there, the user is not trying their best. The system looks at the relationship between consistency and fatigue, with ideal values being a fatigue of about 10 % and a consistency variation of about 0 %. Within each set, the system can collect data relating to each individual stroke. Each stroke in an exercise (or individual exercise movement) can be summarized, with its distance, position, range of motion, energy, fatigue, heart rate, and performance. At the end of each stroke, an intensity parameter, such as a performance index (PI), is calculated. A summary PI is also calculated for each set. A personal trainer can use this data to communicate with the user and identify areas that need to be worked on. The system can preferably automatically update a user profile based on stored settings relating to fatigue and variance.

A reports module **248** can also be provided in communication with the web management module **240**. The reports module can generate user-specific reports based on information from the central database **204**, as well as the measurement module **234**, the caloric intake module **242**, and the fatigue/variance module **246**. Additional modules can include the ability to create custom statistics and measured outcome for published research. The reports module **248** will now be described in further detail.

Reports Module / Kiosk

The system preferably includes a reports module, or kiosk, **248** to generate and provide access to user-specific reports based on measured user performance. In physical implementation, the reports module, or kiosk, **248** can be provided at the computer **220**. In the following description, the kiosk will be described separately, partly since the system can include a plurality of kiosks. The computer **220** centrally manages all data and communicates with all ECs in the system, preferably using wireless technology. The user has the option to login at the kiosk **248** before starting an exercise routine and accept the workout program modified by the system based on results from the previous workout, the amount of consumed calories and the desired goals and objectives. Once completed, the kiosk **248** sends the revised exercise profile to the various EC units for each exercise. At the end of the workout the individual approaches the kiosk, activating the reporting system for outcome summary of measured performance in comparison to their pre-established goals and objectives. A one-page graphical report can be generated, so that the user can evaluate their performance and make the necessary modifications to their exercise routines.

The kiosk software can include various equipment setup parameters and can be used for organizing the various equipment inventories in any club and associating them to various software parameters. All stations are preferably initially characterized prior to first use. The section can include, for example: Equipment calibration screens; Product registration screens; Equipment ID and Data Acquisition Units association screen; Facility setup screen; and Protocol and communication setup screens.

The kiosk software can also include various personal setup screens for entering all personal data including, for example: User personal setup screens; Medical clearance questionnaires and signoff; Various security log-in privileges for other users; Customized exercise program screens; Baseline testing and goal setting screen, anticipated trends; and Battery of standardized templates for creating training programs.

At the beginning and/or completion of any workout, the user or the individual responsible for the user can print various progress reports, manage and create training programs, and enter dietary information. At the end of each workout, the user can have the option to print various progress reports to review effectiveness of the workout. Reports can be summarized in relation to established baseline and planned goals and objectives and can include, for example: One page summary of current workout results (prints automatically at end of workout); and two to three page summary of any number of workouts (user defined data range).

The report module, or reporting engine, **248** can automatically provide these results on-line or to other communication devices including personal digital assistant (PDA), Cell Phone or by email, such as in PDF (portable document format) file format, or any other suitable data format for any other device capable of data communications. Suitable protocols can be used to enable communication between the network module, the identification module, and the performance data and feedback module.

Software/Hardware Implementation

As will be understood by those of skill in the art, the methods of the present invention can generally be embodied as software residing on a general purpose, or other suitable, computer having a modem or internet connection to a communications network. The application software embodying the methods of the present invention can be provided on any suitable computer-useable medium for execution by the computer, such as CD-ROM, hard disk, read-only memory, or random access memory. In a presently preferred embodiment, the application software is written in a suitable programming language, such as C++ or Matlab, and can be organized, into software modules to perform the method steps. The methods could be implemented in a digital signal processor (DSP) or other similar hardware-related implementation.

As such, embodiments of the present invention can be provided as a computer-readable medium including statements and instructions which, when executed by a computer, cause the computer to perform the steps of the method of measuring physical workload for a task, or the method of characterizing a physical performance device, as described above.

Similarly, embodiments of the present invention can be provided as a computer readable medium comprising a data structure. The data structure can include a physical performance index value generated by the method of measuring physical workload for a task, as described above. In another aspect, the data structure can include a physical performance device profile generated by the method of characterizing a physical performance device, as described above.

The above-described embodiments of the present invention are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.

What is claimed is:

1. A method of measuring physical workload for a task, comprising:

receiving task execution data;

calculating an exerted energy value in response to the received task execution data; and

generating a physical performance index value based on the exerted energy value.

2. The method of claim 1 wherein the step of calculating the exerted energy value comprises calculating a work value based on the received task execution data, and determining the exerted energy value based on the calculated work value.

3. The method of claim 1 wherein the received task execution data comprises task baseline data.

4. The method of claim 1 wherein the received task execution data comprises user performance data.

5. The method of claim 1 further comprising, prior to the step of receiving, measuring task execution data.

6. The method of claim 1 wherein the step of generating the physical performance index value based on the exerted energy value comprises multiplying the exerted energy by a machine constant.

7. The method of claim 6 wherein the machine constant is determined based on a ratio of energy exerted in performing the task and a ratio of time spent performing the task.

8. The method of claim 6 wherein the machine constant is determined based on a ratio of energy exerted in performing the task and a machine maximum energy value.

9. The method of claim 1 wherein the machine constant is determined based on a ratio of cylinder force constants.

10. The method of claim 1 wherein the physical performance index value comprises a measure of exercise intensity.

11. The method of claim 1 further comprising displaying a physical performance indicator to a user, the physical performance indicator being determined based on the physical performance index value.

12. The method of claim 1 further comprising determining a user's physical performance based on a comparison of the physical performance index value with a baseline value in a pre-defined profile.

13. The method of claim 1 further comprising determining a user's physical suitability to perform a second task based on a comparison between the physical performance index and a second task baseline value.

14. The method of claim 1 further comprising determining a degree of a user's physical function based on a percentage difference between the physical performance index value and a physical function baseline value.

15. A method of characterizing a physical performance device, comprising:

receiving task execution data;

calculating an exerted energy value in response to the received task execution data;

generating a physical performance index value based on the exerted energy value; and

compiling a physical performance device profile including the physical performance index value.

16. The method of claim 15 wherein the step of calculating the exerted energy value comprises calculating a work value based on the received task execution data, and determining the exerted energy value based on the calculated work value.

17. The method of claim 15 further comprising identifying a functional muscle group associated with the device.

18. The method of claim 15 further comprising determining a machine inefficiency based on a comparison of a measured PI value for the device and a standard device type PI value.

19. The method of claim 15 further comprising, prior to the step of receiving, measuring task execution data.

20. The method of claim 15 further comprising the step of transmitting the physical performance device profile to a storage means.

21. A computer-readable medium including statements and instructions which, when executed by a computer, cause the computer to perform the steps of claim 1.

22. A computer-readable medium including statements and instructions which, when executed by a computer, cause the computer to perform the steps of claim 15.

23. A computer readable medium comprising a data structure, the data structure including a physical performance index value generated by the method of claim 1.

24. A computer readable medium comprising a data structure, the data structure including a physical performance device profile generated by the method of claim 15.

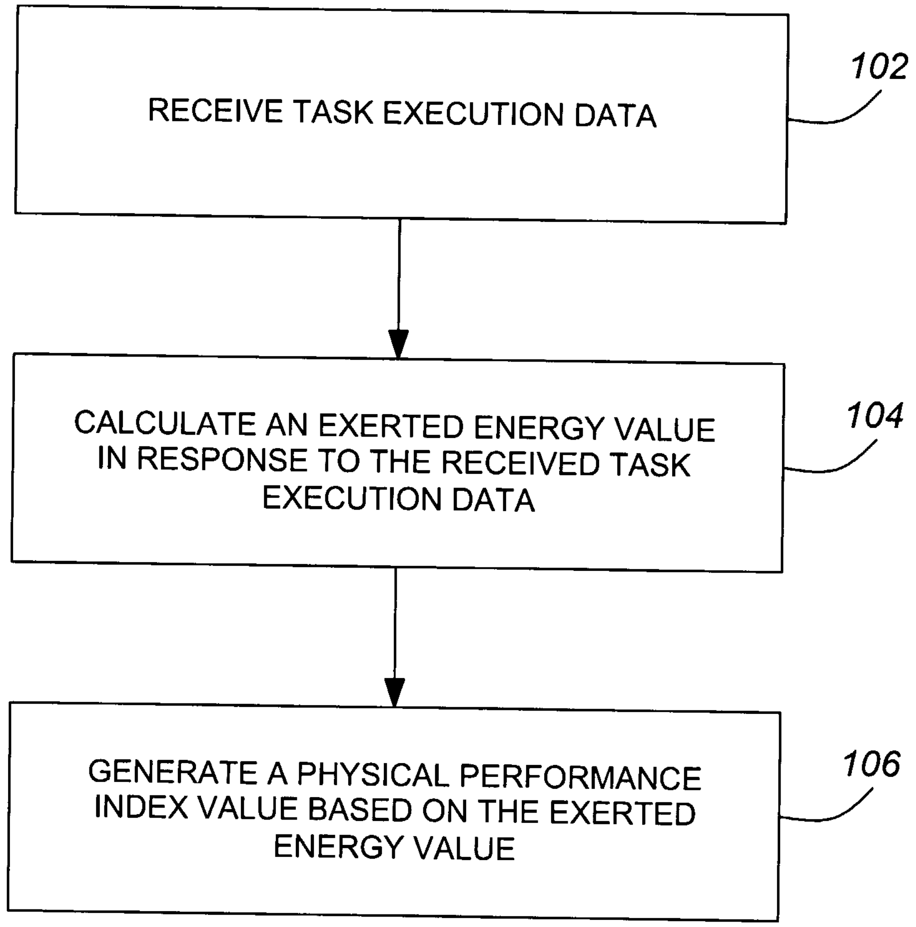

RECEIVE TASK EXECUTION DATA
102
CALCULATE AN EXERTED ENERGY VALUE IN RESPONSE TO THE RECEIVED TASK EXECUTION DATA
104
GENERATE A PHYSICAL PERFORMANCE INDEX VALUE BASED ON THE EXERTED ENERGY VALUE
106

FIG. 1

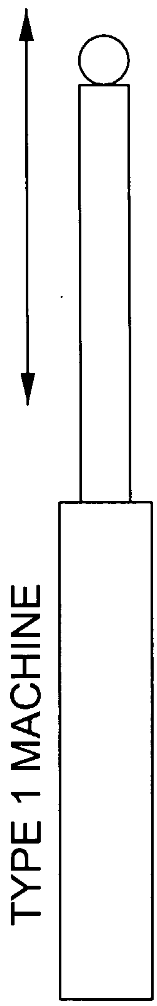


FIG. 2A

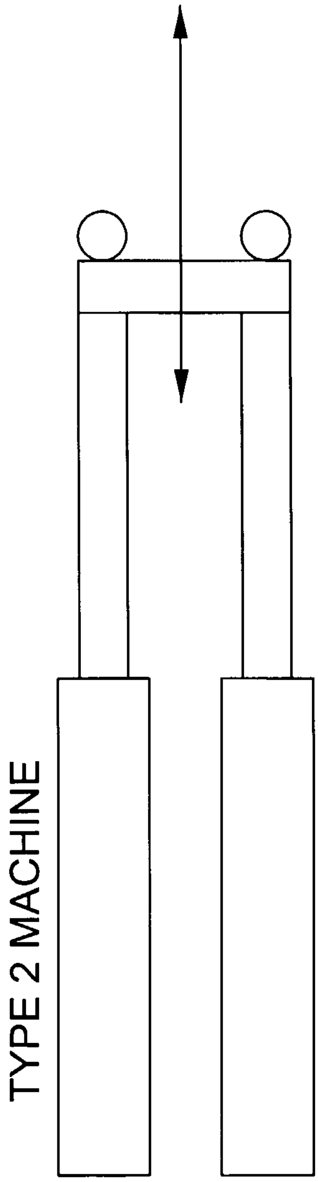


FIG. 2B

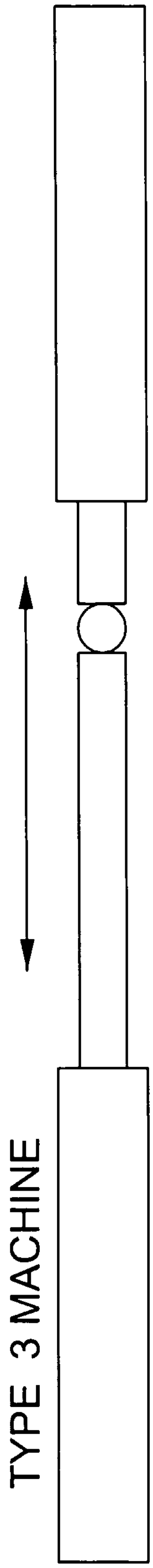


FIG. 2C

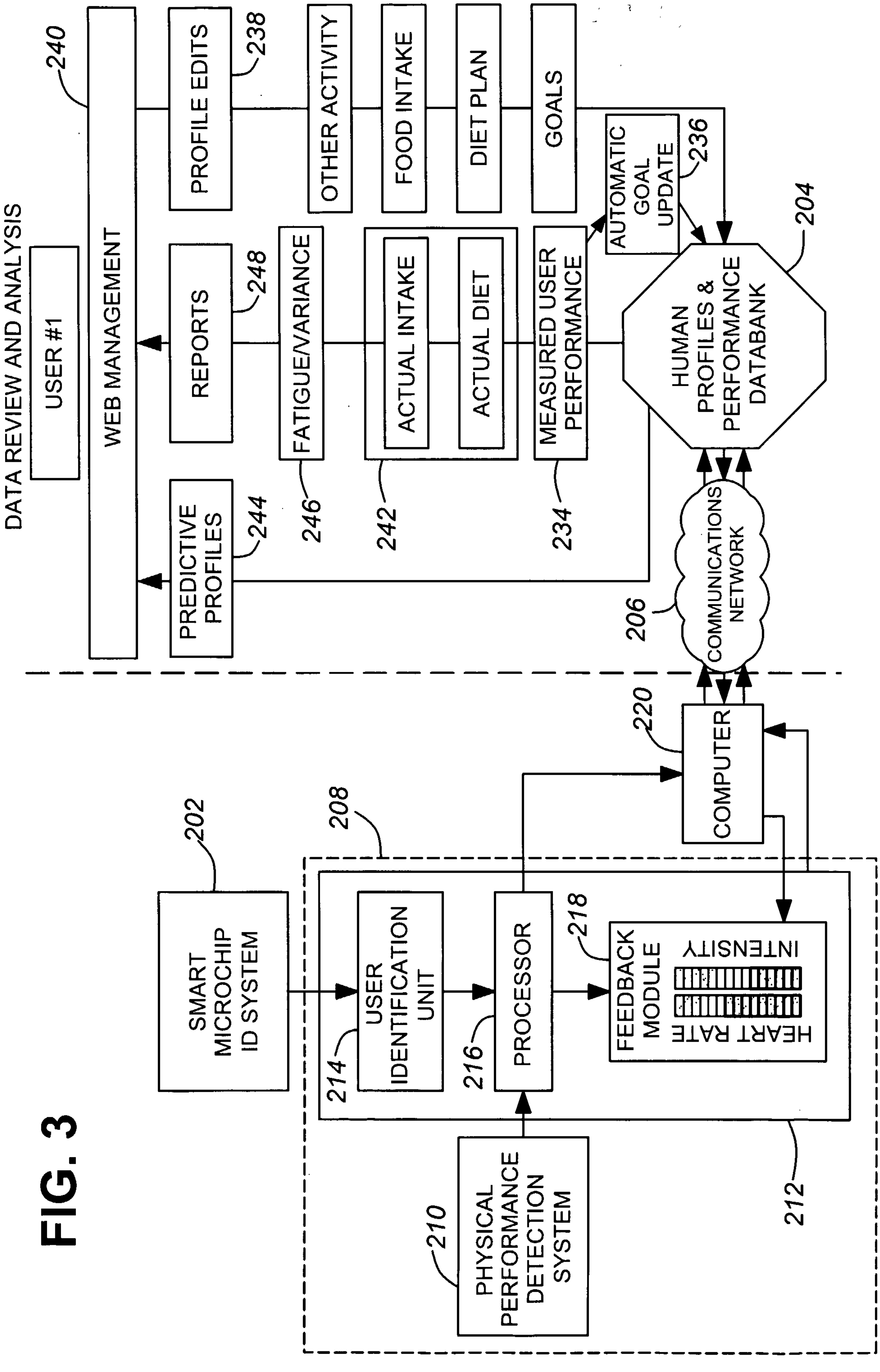

DATA REVIEW AND ANALYSIS
USER #1
WEB MANAGEMENT
240
PREDICTIVE PROFILES
244
REPORTS
248
PROFILE EDITS
238
FATIGUE/VARIANCE
246
ACTUAL INTAKE
ACTUAL DIET
242
OTHER ACTIVITY
FOOD INTAKE
DIET PLAN
GOALS
MEASURED USER PERFORMANCE
234
AUTOMATIC GOAL UPDATE
236
HUMAN PROFILES & PERFORMANCE DATABANK
204
COMMUNICATIONS NETWORK
206
COMPUTER
220
208
SMART MICROCHIP ID SYSTEM
202
USER IDENTIFICATION UNIT
214
PROCESSOR
216
FEEDBACK MODULE
218
HEART RATE
INTENSITY
PHYSICAL PERFORMANCE DETECTION SYSTEM
210
212

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2005/001620

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***A61B 5/22*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B using keywords

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Delphion, Canadian Patent Database, EspaceNet, USPTO using keywords physical, workload, task, execution, exert*, energy, index

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6743167 (Balkin et al) June 1, 2004 Abstract, Cols 32-34	1-24
A	US 20010056241 (Nissila) December 27, 2001 Abstract, Figure 1B, Pages 4-6	1-24
A	EP 1391179 (Kostucki) February 25, 2004 Abstract, Figures 2-4	1-24

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 February 2006 (14-02-2006)	23 February 2006 (23-02-2006)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001(819)953-2476	Saadia Saifuddin (819) 934-2671

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2005/001620

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20040147814 (Zancho et al.) July 29, 2004 Pages 5-6	1-24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/CA2005/001620

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
EP1391179	25-02-2004	EP1510175 A1	02-03-2005
US2004147814	29-07-2004	NONE	
US2001056241	27-12-2001	EP1133950 A2	19-09-2001
		FI114200B B1	15-09-2004
		US6443904 B2	03-09-2002
US6743167	01-06-2004	AT302976T T	15-09-2005
		AU758024 B2	13-03-2003
		AU6134599 A	22-05-2000
		BR0207959 A	20-07-2004
		CA2349561 A1	11-05-2000
		CA2439942 A1	19-09-2002
		DE69926904D D1	29-09-2005
		EP1125237 A1	22-08-2001
		EP1365682 A2	03-12-2003
		JP2002529121T T	10-09-2002
		JP2005506601T T	03-03-2005
		US6241686 B1	05-06-2001
		US6527715 B2	04-03-2003
		WO0026841 A1	11-05-2000
		WO02073343 A2	19-09-2002