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(54) **TRAINING DEVICE FOR DETERMINING TIMING OF NEXT TRAINING SESSION**

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(57) **ABSTRACT**

A device helps a user to plan the proper timing for setting a next training session based on the intensity of a training stimulus of a previous session. The user is shown when there will have been enough recovery time since the last training session to suggest the best time for starting the next training session. The timing recommendations are based on a super-compensation time curve that depends on a user dependent factor that includes at least the training load of the last training session and preferably also depends on the training status of the user. Further parameters like age and gender and variables like behavior affecting recovery, as there are for example tiredness from lack of sleep, dehydration from insufficient drinking, insufficient calories, protein, mineral or vitamin intake, consumption of alcohol and other drugs, can additionally be used to influence the recovery timing calculations.

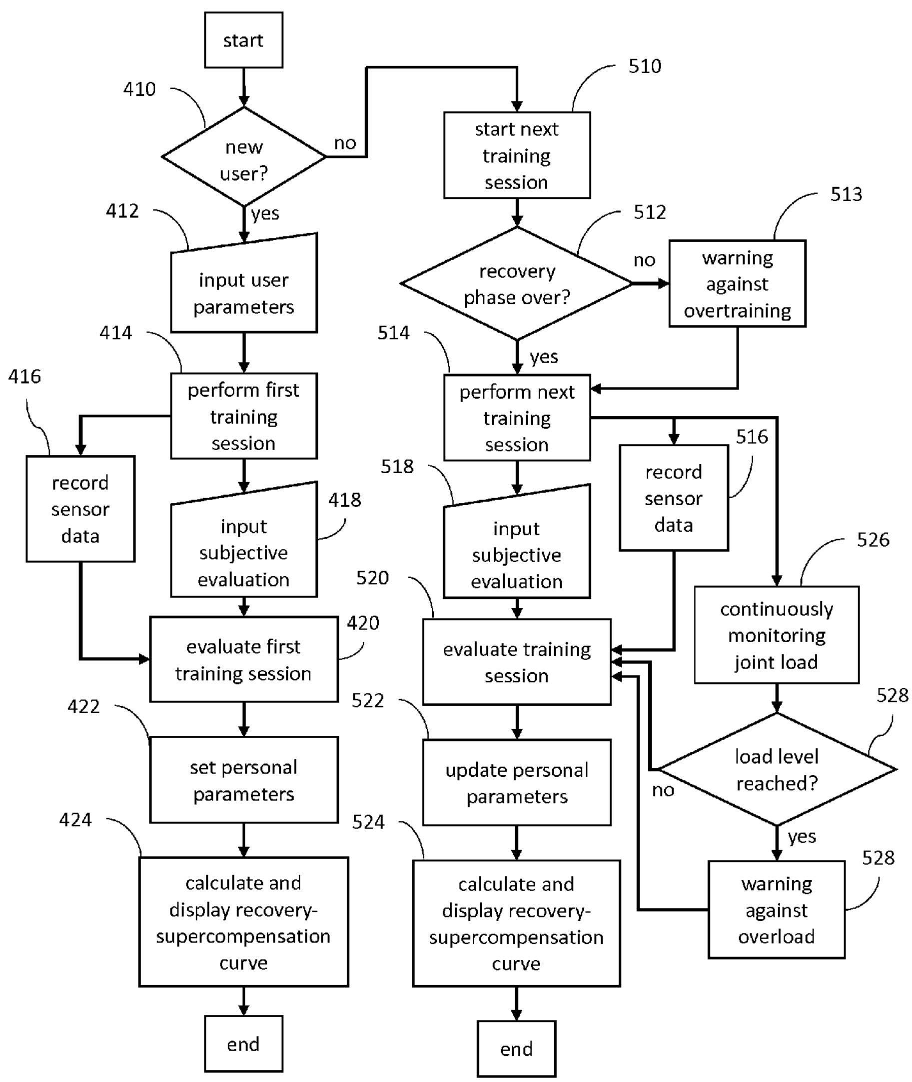


Fig. 1a

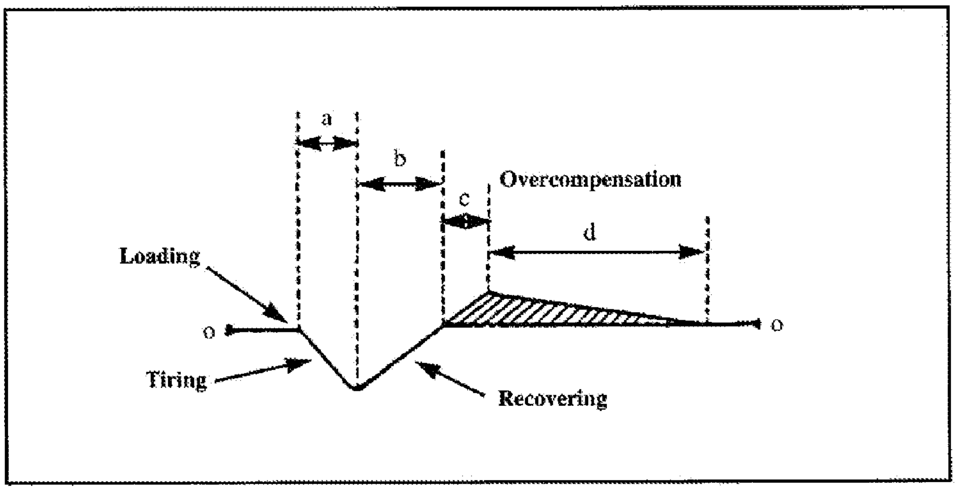

a
b
c
Overcompensation
d
Loading
o
o
Tiring
Recovering

Fig. 1b

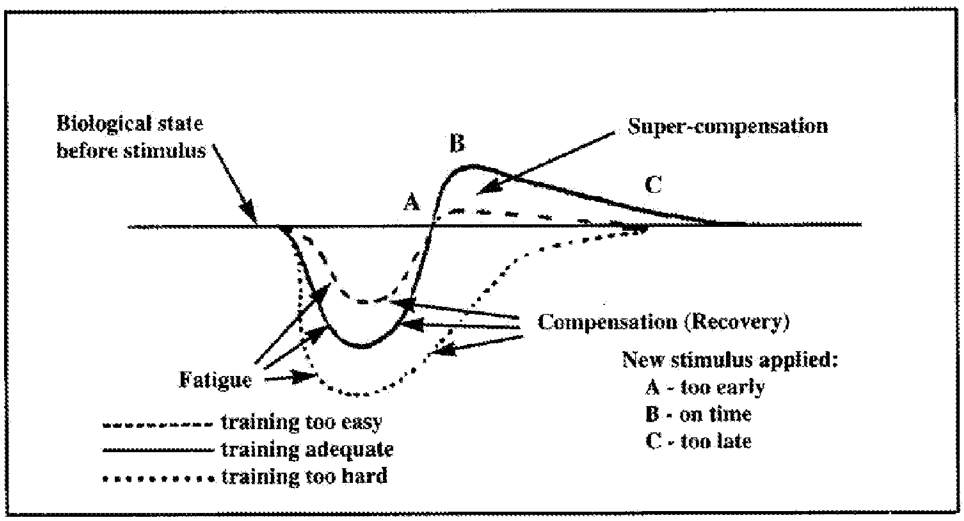
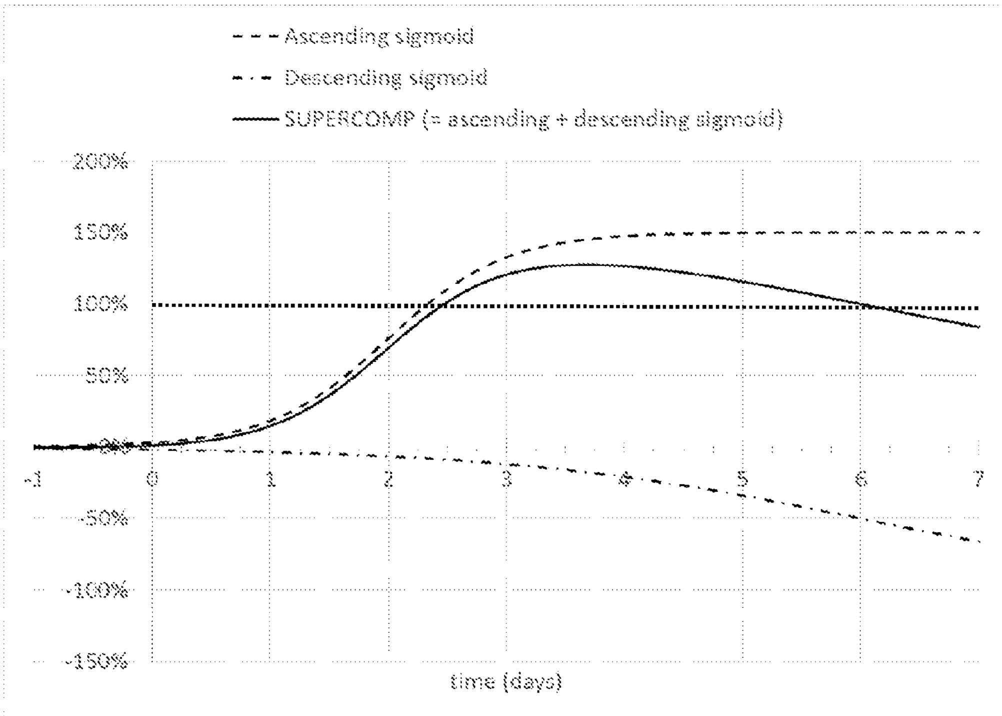
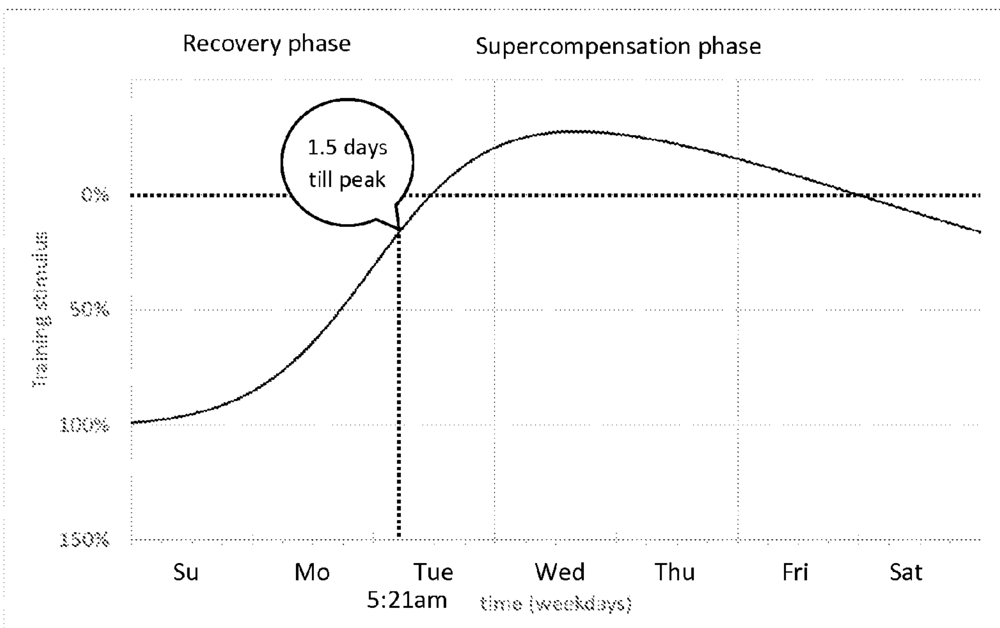

Biological state
before stimulus
Super-compensation
B
A
C
Compensation (Recovery)
Fatigue
New stimulus applied:
A - too early
B - on time
C - too late
training too easy
training adequate
training too hard

Fig. 2a



Ascending sigmoid
Descending sigmoid
SUPERCOMP (= ascending + descending sigmoid)
200%
150%
100%
50%
0%
-50%
-100%
-150%
-1
0
1
2
3
4
5
6
7
time (days)

Fig. 2b



Recovery phase
Supercompensation phase
1.5 days till peak
0%
50%
100%
150%
Training stimulus
Su
Mo
Tue
5:21am
Wed
Thu
Fri
Sat
time (weekdays)

Fig. 3

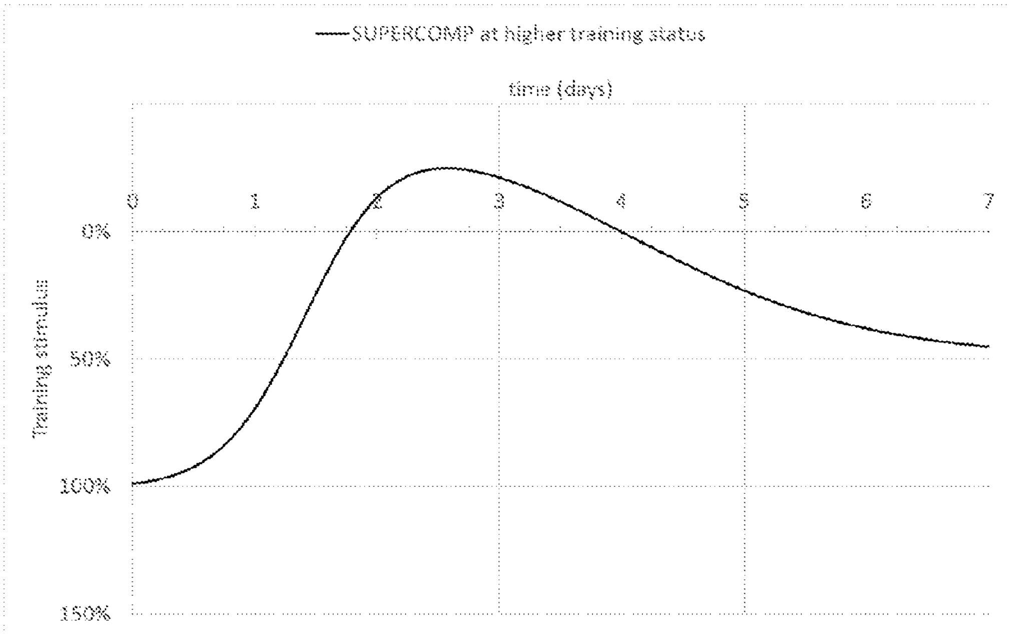

SUPERCOMP at higher training status
time (days)
0
1
2
3
4
5
6
7
0%
50%
100%
150%
Training stimulus

Fig. 4

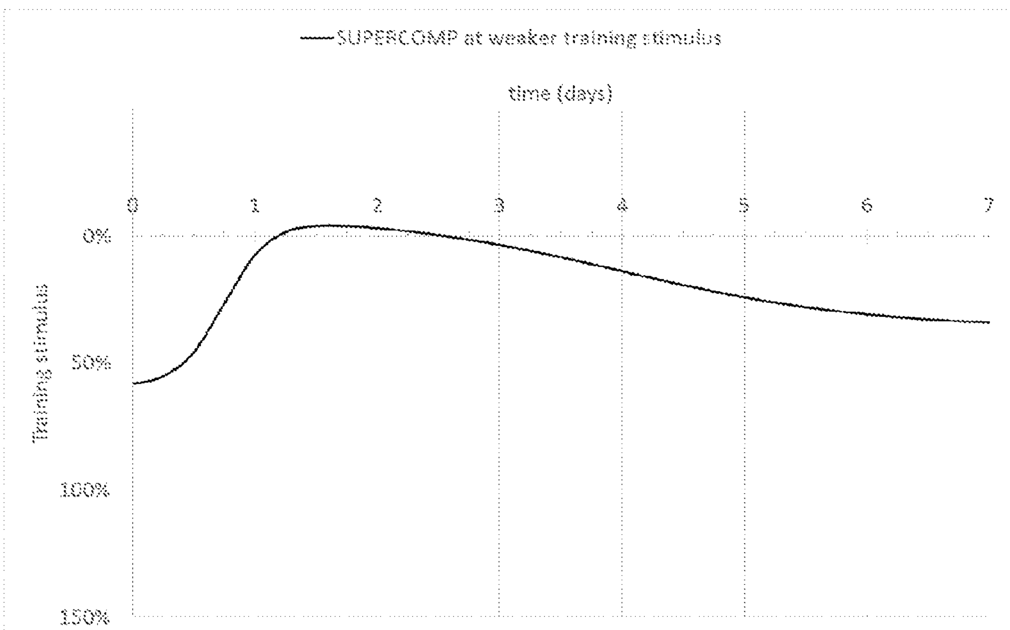

SUPERCOMP at weaker training stimulus
time (days)
0
1
2
3
4
5
6
7
0%
50%
100%
150%
Training stimulus

Fig. 5

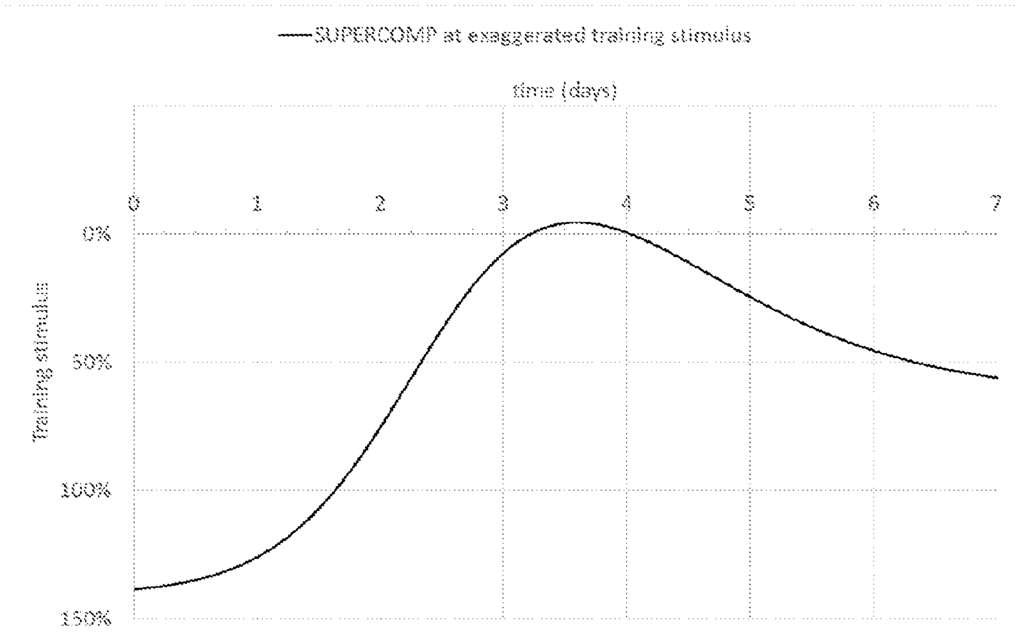

SUPERCOMP at exaggerated training stimulus
time (days)
0
1
2
3
4
5
6
7
0%
50%
100%
150%
Training stimulus

Fig. 6

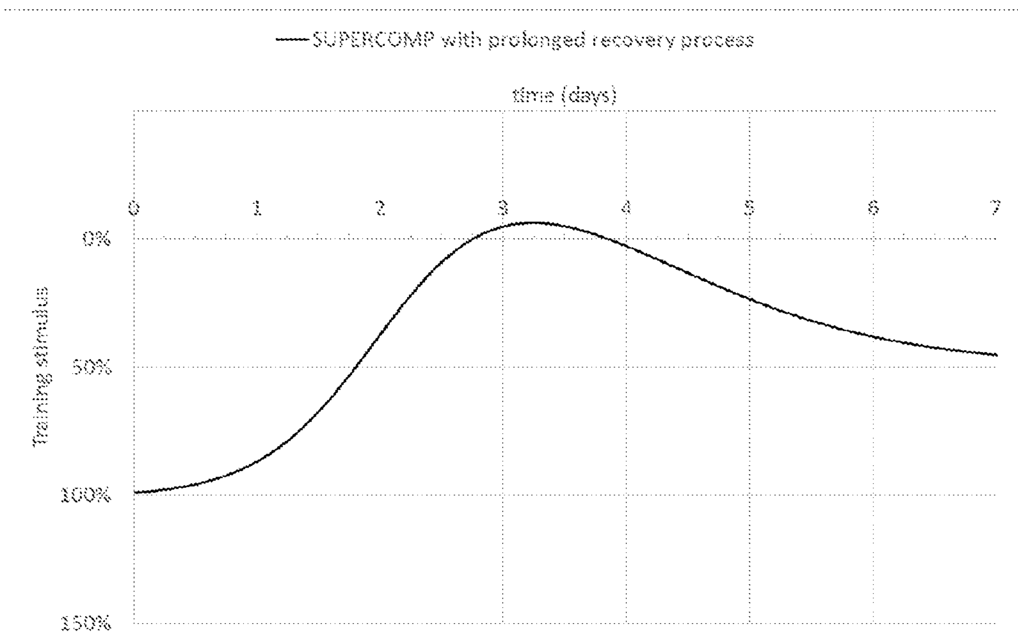

SUPERCOMP with prolonged recovery process
time (days)
0
1
2
3
4
5
6
7
0%
50%
100%
150%
Training stimulus

Fig. 7

Activity	amount/week	Training status
modest physical activity (e.g.walking)	<1h	2
modest physical activity (e.g.walking)	>1h	3
regular physical exercise (e.g. running)	<0.5h	4
regular physical exercise (e.g. running)	0.5h - 1h	5
regular physical exercise (e.g. running)	1h - 3h	6
regular physical exercise (e.g. running)	3h - 5h	7
regular physical exercise (e.g. running)	5h - 7h	7.5
training almost daily	7h - 9h	8
training daily	9h - 11h	8.5
training daily	11h - 13h	9
training daily	13h - 15h	9.5
training daily	>15h	10

Fig. 8

	time_a	gain_a	offset_a	time_d	gain_d (2/3 of gain_a)	offset_d (2/3 of gain_a)
Training status 5 (recreational)	1	0.75	0.75	0.333	0.5	0.5
Training status 7.5 (athletic)	1,5	0.75	0.75	0.5	0.5	0.5
Delayed recovery	1	0.75	0.75	0.5	0.5	0.5
Weak training stimulus	3	0.25	0.75	0.5	0.167	0.167
Overtraining	0,75	1.25	0.75	0.5	0.833	0.833

Fig. 9

Training stimulus	Training status 5 (recreational) time_a	Training status 7.5 (athletic) time_a	gain_a	offset_a
10%	5.25	7	0.05	0.95
20%	4.5	6	0.1	0.9
25%	4.125	5,5	0.125	0.875
30%	3.75	5	0.15	0.85
40%	3	4	0.2	0.8
50%	2.25	3	0.25	0.75
75%	1.5	2	0.5	0.75
100%	1	1.4	0.75	0.75
125%	0.7	1	1	0.75
150%	0.54	0.8	1.25	0.75
175%	0.47	0.7	1.5	0.75
200%	0.43	0.65	1.75	0.75

Fig. 10

Recovery	Examples	time_a correction factor
Exceptionally good	taking walks + diet + massages	1.15
very good	taking walks + recovery diet	1.1
good	taking walks	1.05
normal	eating, drinking and sleeping enough, full abstinence	1
mediocre	one of the above line below normal	0.9
bad	two below normal or one quite low	0.8
very bad	one very low or several quite low	0.7

Fig. 11

Value of the recovery-supercompensation curve between	and	Color code	Text message
below 0%	0%	CadetBlue (blue-gray)	you need to recover for upcoming exercise
0%	25%	LightSeaGreen (grayish blue-green)	keep on recovering for upcoming exercise
25%	50%	DarkSeaGreen (blue-green)	you better take more time to recover
50%	75%	MediumSeaGreen (warm blue-green)	you are almost recovered
75%	100%	YellowGreen (warm green)	you are about to gain extra energy
100%	115%	Amber (ascending superc. phase)	your energy is growing, soon it will hit the peak
115%	above	Orange (top superc. phase)	you are overflowing with energy - now get it on!
115%	100%	Ochre (descending superc. phase)	you are losing energy - get it on now!
100%	below	YellowGreen (warm green)	it's about time for an exercise

Fig. 12

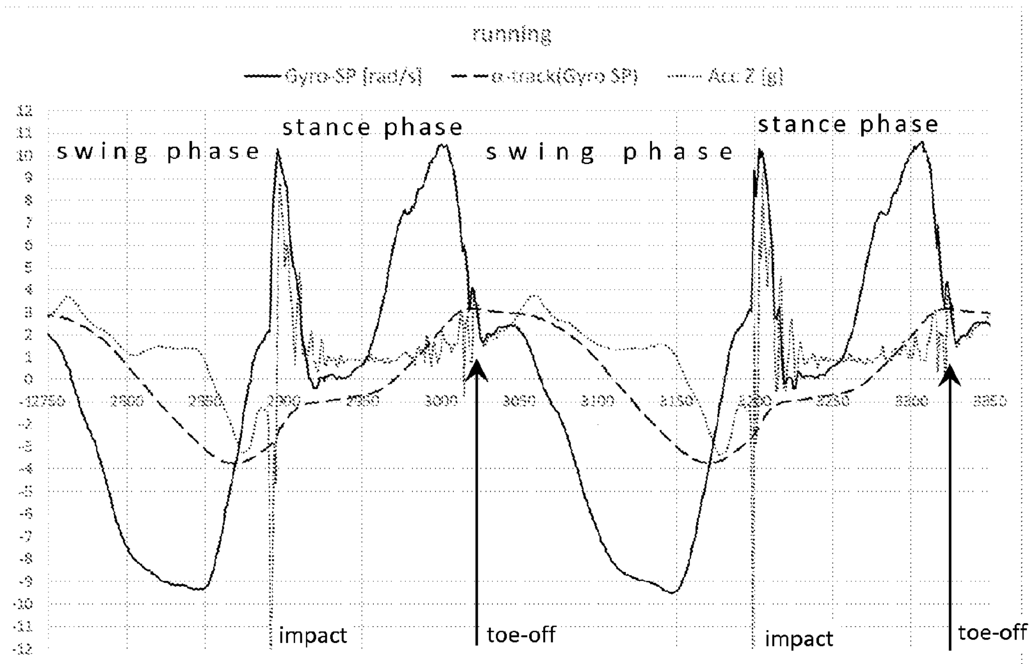

running
Gyro-SP [rad/s]
α-track(Gyro SP)
Acc Z [g]
swing phase
stance phase
swing phase
stance phase
impact
toe-off
impact
toe-off

Fig. 13a

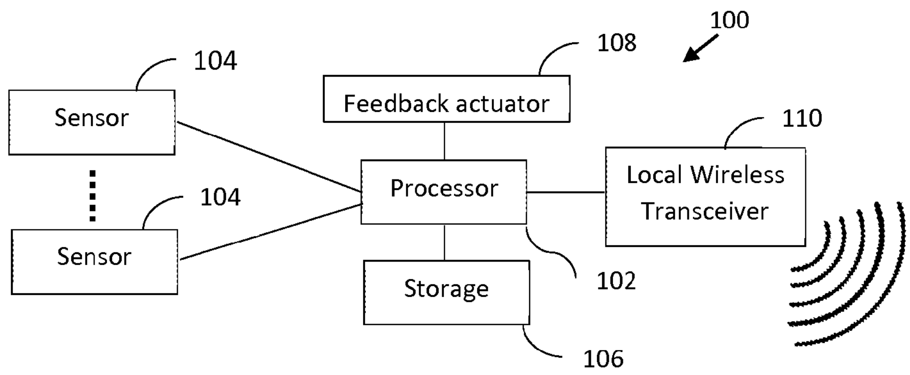


Fig. 13b

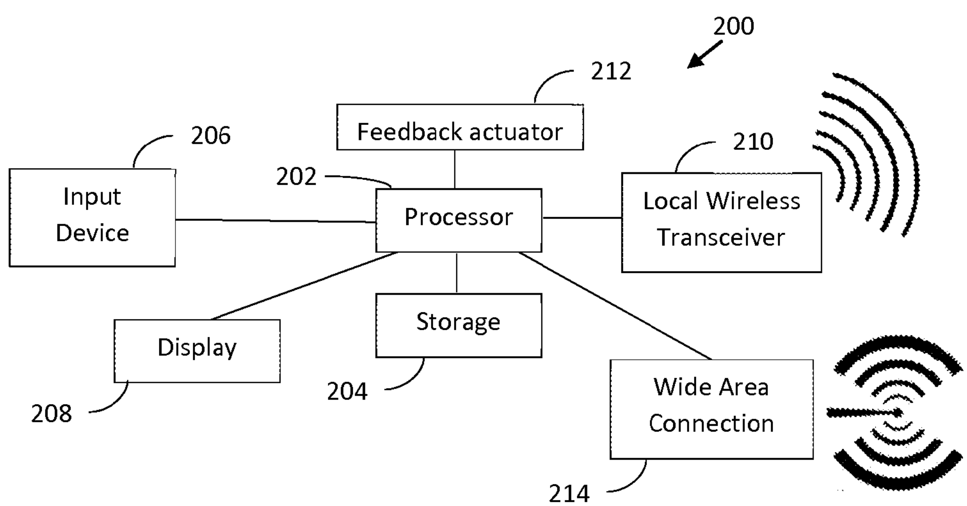


Fig. 13c

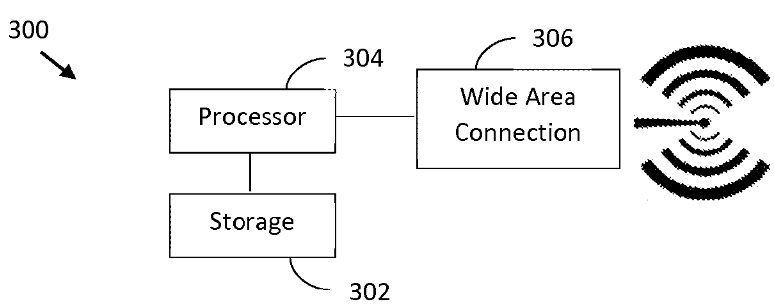


Fig. 14

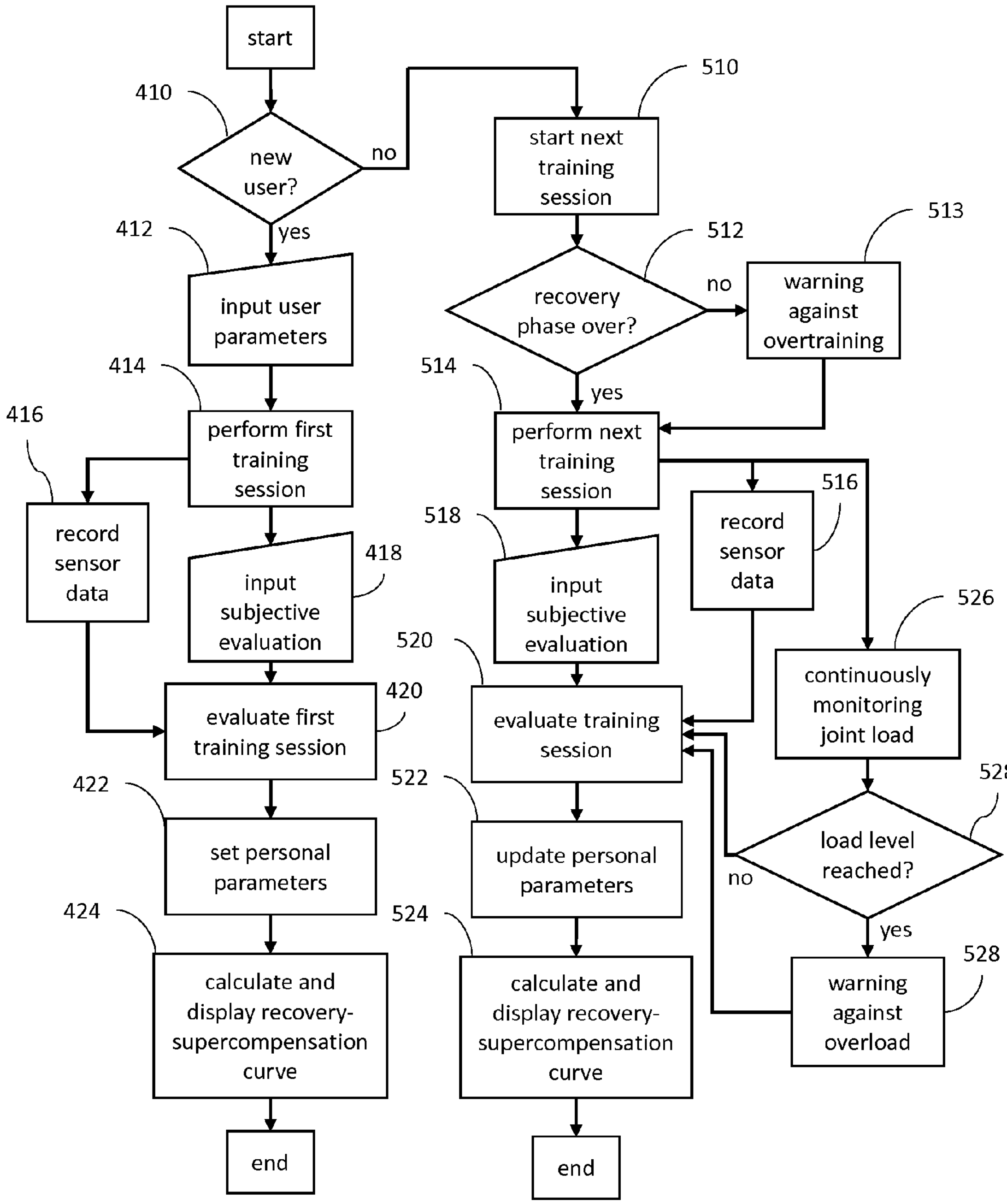
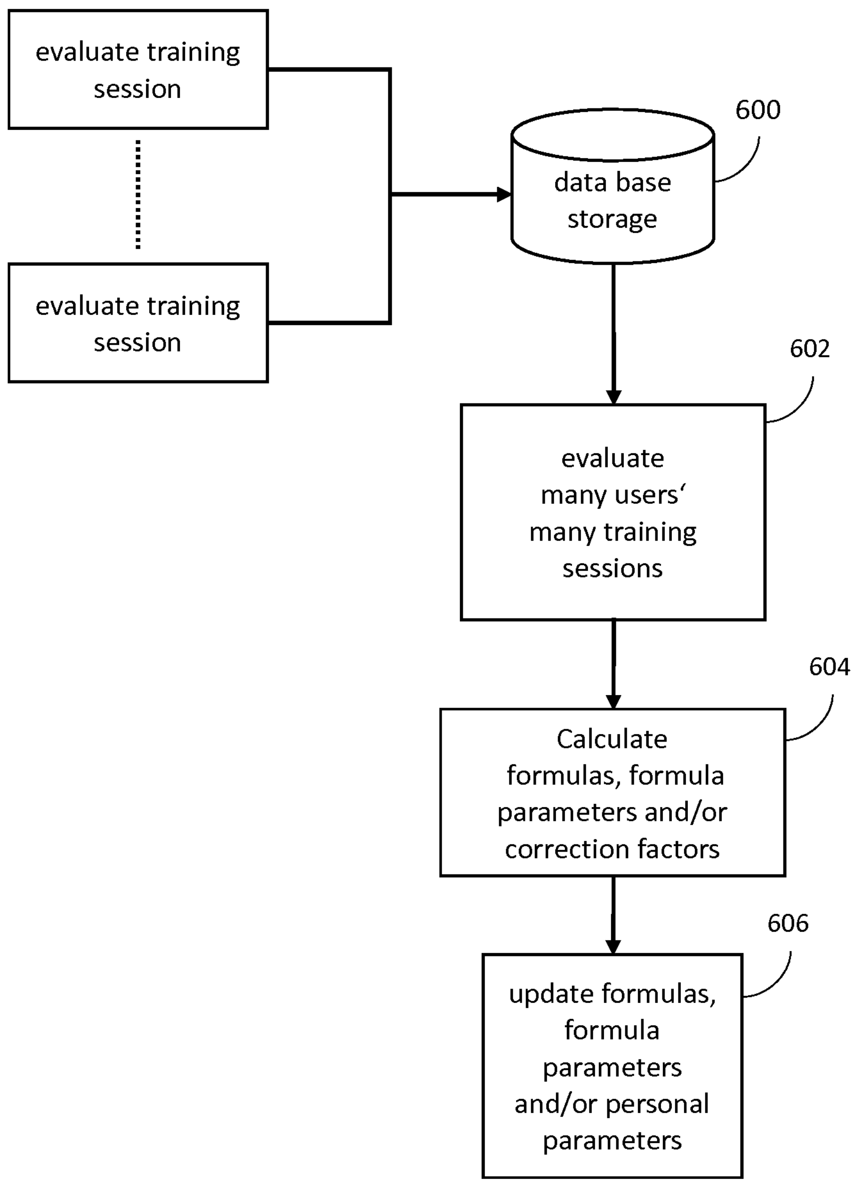

start
410
new user?
no
yes
412
input user parameters
414
perform first training session
416
record sensor data
418
input subjective evaluation
420
evaluate first training session
422
set personal parameters
424
calculate and display recovery-supercompensation curve
end
510
start next training session
512
recovery phase over?
no
513
warning against overtraining
yes
514
perform next training session
516
record sensor data
518
input subjective evaluation
520
evaluate training session
526
continuously monitoring joint load
528
load level reached?
no
yes
528
warning against overload
522
update personal parameters
524
calculate and display recovery-supercompensation curve
end

Fig. 15


evaluate training session
evaluate training session
data base storage
600
602
evaluate many users' many training sessions
604
Calculate formulas, formula parameters and/or correction factors
606
update formulas, formula parameters and/or personal parameters

TRAINING DEVICE FOR DETERMINING TIMING OF NEXT TRAINING SESSION

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a device and a method providing a technical aid for physical exercise which instructs the user on proper timing for setting the next training session on account of the intensity of the training stimulus of the previous training session. The best time for performing the next training session is a time window, which only starts after a proper recovery time after the previous training session and is based on the training principle of recovery and supercompensation.

[0002] Training is effective because the body is seeking to adapt to the stress from its environment. A training stimulus is the application of stress (the training load) and a training effect is the body's subsequent adaptation to that stress. In training, the desired adaptive response, i.e., the ability of the body to better cope with similar stress situations in future, is described by a process called supercompensation.

[0003] The supercompensation model illustrating the effect of a training load is shown in FIGS. **1***a* and **1***b*. The first step is the application of a training load or stress, i.e., exercise, resulting in fatigue or tiring and the body's subsequent reaction to this training load (phase a in FIG. **1***a*). The following step is the recovery phase (phase b in FIG. **1***a*). As a result of the recovery period, the energy stores and performance will return to the baseline defined as the performance potential just before the application of the original training stress (the horizontal line, designated "biological state before stimulus" in FIG. **1***b*). The next step is the supercompensation phase (also referred to as overcompensation). This is the adaptive rebound above the baseline (phase c in FIG. **1***a*). The following step in the process is the loss of the supercompensation effect (phase d in FIG. **1***a*). If no training stress is applied for a longer period of time, there will be a decline in performance potential and the curve will eventually drop below the baseline (not shown in FIG. **1**). This is the so-called detraining phenomenon. The aim, however, is to apply a new and proper training load within the proper time window, in particular within the supercompensation phase, which will increase the performance potential on the long run.

[0004] The recovery-supercompensation model is a widely used representation of the training process and graphically represented in nearly every textbook on training.

[0005] A different explanation is the so-called two-factor theory, or fitness fatigue model, from Banister and colleagues, with two exponential decay functions. The premise is that the fatigue effect of training is of shorter duration but of greater magnitude while the fitness effect of training is slower changing and longer lasting (often regarded as three times slower). The basic idea was to predict the performance potential on a longer time scale, in particular when scheduling training cycles. However, the predictive accuracy proved to be insufficient and fitting model parameters to actual individual training data leads to such a high variation in time parameters that any physiological meaning, if there was any, is lost. The same holds true for the other model suggested in the literature, the performance potential model (Pfeiffer 2014, International Journal of Computer Science in Sport, Volume 7 Edition 2, 13-32). Moreover, the fitness fatigue model cannot express overtraining, while the performance potential model has an overflow term to particularly model breakdown of performance after overtraining. However, the performance potential model cannot model the supercompensation effect of a single training load at all, rather it only models long term effect of continuous training loads. Brueckner 2008 (E-Journal Bewegung and Training, 2 (2008), 51-65) and Brueckner 2006 (PhD Thesis, Christian-Albrechts-Universität zu Kiel) [both in German] developed a model similar to the performance potential model with flow rates, but which is able to model the supercompensation effect of a single training load. However, the supercompensation effect modeled is proportional to the training load, which is also the case in a single overload of excessive training, therefore failing to model the lack of positive training effect after excessive training. He found that his model's parameter can be derived by fitting to 3 weeks of training data, after which the prognostic quality for one week of further training is fairly good, but thereafter mediocre.

[0006] Another model put forward by Mader 1990 (Deutsche Zeitschrift f. Sportmedizin, 41(2), 40-58 [in German]) "simply" tries to model the turnover of the underlying biological components by differential equations. However, many of the regulative components are still to be discovered and only on very few components good time course information is available. And even if successful one day, the resulting calculation model will certainly not be simple and easy to handle at all.

[0007] The known quantitative models try to explain more or less the basic training phenomenon, which is still hardly understood in terms of physiology. Historically, the description of supercompensation in sports goes back to the Russian physiologist Jakovlev who observed that the re-synthesis of glycogen stores in muscle after exercise not only fills up but overshoots for a short period of time. Jakovlev himself built on work of earlier researchers, too, in particular the German pathologist Weigert on wound healing, the famous Russian researcher I. P. Pawlow on pancreatic function, his student G. V. Folbort on heart recovery and on the Russian biochemist Engelgard. In fact, Jakovlev explicitly referred to the phenomenon as Engelgard's principle. Jakovlev also found it in creatine phosphate, enzymatically and structural muscle proteins, phospholipids and the quantity of mitochondria within the muscle fibers and the quantity of muscle fibers themselves. Jakovlev realized, that the energetic supercompensation after muscle work has a prominent role for the re-synthesis for proteins and adaptations to future loads resulting in a structurally and physiologically stronger muscle.

[0008] Interestingly, it was found more recently that reactive oxygen species (ROS) actually work as a signal from stressed mitochondria to induce the repair and adaptation process. For review see Powers 2009 (Exp Physiol 95 p. 1-9), Powers 2011 (J. Physiol. 589, 2129-2138). Indeed, it could be shown that taking a lot of antioxidants actually prevents the training effect of exercise as well as the health promoting effects of exercise (Ristow 1990, PNAS 106, p. 321-333).

[0009] There is very limited quantitative data on supercompensation timing and therefore it is used as an explanatory principle rather than as a calculation model. The German textbook of Grosser, Brüggemann and Zintl of 1986 states in the diagram on p. 11 the recovery phase (to the point of the maximal supercompensation) a time frame of 2 to 3 days and the beginning of the fading of the supercompensation effect at latest after 3 days (reproduced on above mentioned PhD Thesis Brueckner 2006, p. 13). However, the usefulness of the supercompensation model has also been heavily criticized, in particular by Mader 1990 (Deutsche Zeitschrift f. Sportmedizin 41(2), p. 40-58 and Friedrich & Moeller 1999 (Leistungssport 5 p. 52-55) [both in German language]. More discussion [all in German languages] on the subject can be found in Tschiene 2006 (Leistungssport January 2006, p. 5-14), Platonov 2008 (Leistungssport February 2008 p. 15-20), Hottenrott & Neumann 2010 (Leistungssport February 2010, p. 13-19).

[0010] One of the issues is that various physiological entities have different time courses of recovery and supercompensation. Restoration of glycogen stores is certainly faster than building up of new mitochondria, with measures on fitness level lying in between. For an illustration see Heterochronism_of_adaptation.svg in http://en.wikipedia.org/wiki/Supercompensation.

The most important point, which was originally pointed out by Jakovlev, however, is to re-build and better over-fill (supercompensate) the energy stores before the next training in order that the body has enough energy for the anabolic processes of the more long term adaptations while at the same time using up energy during the next training work. Therefore alone the knowledge of a minimal recovery time, at which all the more short term recovery processes have been finished and the more long term effects have at least progressed to some extent, is of a big benefit.

[0011] To cope with the long term adaptations it is well known in sports training to alternate a few periods of heavy training load with a period of little load, and, in longer time frames, use seasonal alternations in order to allow recovery of longer lasting anabolic processes. This has been described under the term periodization in Periodization—Part I (National Strength and Conditioning Association (NSCA) Journal Volume 15(1), 1993, p. 57-67). Further discussion [all in German language] can be found in Verchoshanskij 1998 (Leistungssport May 98, p. 14-19), Platonov 1999 (Leistungssport January 99 p. 13-17) and Selujanov 1999 (Leistungssport February 99, p. 13-14).

[0012] The main other criticisms on the supercompensation "model" were that it is purely descriptive without explaining the underlying mechanism, that it lacks differentiation on age, on gender, on training status and on individual training capabilities Friedrich & Moeller 1999 (Leistungssport 5 p. 52-55). In fact, from a quantitative point of view, there is no model of supercompensation, none of the discussion literature referred to mathematical models of calculating supercompensation.

[0013] In a singular piece of evidence on the influence of age on the timing of the supercompensation process for an athlete, the peak of the supercompensation point was estimated on one well trained person with his increasing age and be found to be 60 hours (2.5 days) at 47 years of age, 75 hours (3.1 days) at 53 years of age and 88.3 hours (3.7 days) at 58 years of age (Mitsumune & Kayashima 2013, Asian J Sports Med 4, 295).

[0014] In view of the above discussion, it can be gathered that supercompensation is widely used as an explanatory principle to teach the training effect, but actual training planning is mostly based on experience rather than on quantitative science. The existing quantitative training models try to calculate future performance of an athlete by fitting the model to historic training data of that athlete, however, the predictive quality is regarded as insufficient at least for training advice for high-level athletes. None of the quantitative models can mimic the supercompensation effect after a training session and dependent on the particular load of that last training to comply with the figure of Klavora p. 6 which can be found reprinted in Periodization—Part I, National Strength and Conditioning Association Journal 15 (1), 1993, p. 57-67 on p. 62 and attached here as FIG. **1***b*.

[0015] Devices and methods to support the athlete in their training planning and timing are known.

[0016] WO2013/132141 discloses a system, method and computer program product for gaining a balanced health and fitness regime, including a user interface configured for receiving and displaying information regarding muscle recovery times of workouts of a user. It provides the user via a device with a method and an interface to track, analyze and learn post exercise recovery (e.g. supercompensation) times (paragraph 0029). It further discloses that the recovery time may depend on the status of the user and specifically suggests a preset of 5 days for an athlete and 7 days for a recreational user at 80% of the total workload (paragraph 0042). It further takes into account that the recovery time depends on the workload of the previous session and discloses a method to individually calibrate and fine tune the recovery time depending on the workload of the previous session by specific manual input screens (paragraphs 0046 and 0047). It also discloses that it provides the user with tools for entering recovery influencing behavior like sleep, quality of nutrition or stress level and for entering the user's subjective feeling e.g. muscle soreness a couple of days after working out, including Delayed Onset Muscle Soreness (DOMS), etc. (paragraph 0044). Although WO2013/132141 discloses a system for teaching the user the proper recovery time before starting the next training session and can be individualized to a wide extent, it restricts this to a single number of minimal recovery time and fails to give any method of calculating the supercompensation curve or to teach the user how the shape of a supercompensation curve would depend on the workload of the last training session. Therefore it cannot to teach the user that excessive training diminishes potential training benefits from supercompensation, or that a weak training diminishes potential training benefit from supercompensation, or that a very long recovery time will lead to a decline and eventually loss of the supercompensation benefit.

[0017] U.S. Pat. No. 8,348,809B2 describes a device that suggests a higher or lower training load in the next training session on account of the measured history of the previous training loads "thereby stimulating mechanical loadability of the user through supercompensation" (last feature of claim 1).

[0018] US2014/0134584 discloses the general concept of determining a timing of a next training session. It discloses a system that is used to determine quantitatively the effects of training load, intensity, and duration of each training session (paragraph 0091). Results from numerous tests can serve as a basis to plot the subject's actual stress-breakdown-recovery-supercompensation curve (paragraph 94). FIGS. 11-14 show that tests are performed to determine when the subject reaches the supercompensation stage (e.g. FIG. 14). Although US2014/0134584 discloses that a supercompensation cycle could be drawn on a multitude of test results on a user, it also fails to disclose, teach or suggest the calculation of the supercompensation curve with a mathematical model. Therefore it cannot teach the user that excessive training diminishes potential training benefits from supercompensation unless the user actually experiences a decline in performance after several excessive training loads (paragraph 0133) and measured with the suggested multitude of performance measurements (e.g. FIG. 8). Further it cannot teach the user that a weak training diminishes potential training benefit from supercompensation unless the user actually fails to experience an increase in performance after several weak training loads and measured with the suggested multitude of performance measurements. This leads to a strong problem: in case the user would not perform the suggested multitude of performance tests very often, i.e. several time within one supercompensation cycle and therefore much more frequently than the training sessions themselves, the user is unable to distinguish whether the reason for a failure to experience an increase in performance after several training sessions is actually caused by not enough recovery time, by excessive training load, by too weak training load, or by too long a recovery time. A recreational user doing performance tests only at the beginning of a training session and not in between two of them would be completely unable to get enough data points to "define the subject's actual real training curve" (paragraph 0093). However, typically athletes and even more so recreational users do performance tests at a low frequency, much lower than the frequency of training sessions themselves, making the disclosed method useless for them.

[0019] US 2007/0293371 is pertinent in that it provides a computation of a regeneration condition (paragraphs 0044-0047), however it fails to disclose defining a calculation method of defining the supercompensation curve or any calculation method indeed.

[0020] For measuring a training load, most prior art is based on heart rate monitoring. The Polar wristwatches are for example described in U.S. Pat. No. 7,914,418 B2 and U.S. Pat. No. 8,512,238 B2, the Suunto wristwatches in US 2011/263993 A1, US 2012/215116 A1, US 2013/339409 A1 and US 2014/018945 A1. Firstbeat Technologies describe their methods in US 2006/004265 B2, US 2006/032315 B2, US 2009/069156 B2, US 2010/216601 B2, WO 2009/133248 A1, WO 2012/140322 A1 and WO 2013/068650 A2 as well as in three white papers: "An Energy Expenditure Estimation Method Based on Heart Rate Measurement", "Indirect EPOC Prediction Method Based on Heart Rate Measurement" and "EPOC Based Training Effect Assessment", available on the company's website.

[0021] However, the prior art does not disclose, teach, or suggest a calculation method for the supercompensation curve or presenting a supercompensation curve depending on individual parameters to teach the user at which time point of the supercompensation he or she is according to the recovery time after the last training session or teach the user how the form of the supercompensation curve dependent on the load of the last training session will provide a time window (the supercompensation window) for optimal timing for a next training session and whether the work load of the last training session will give a more or less pronounced supercompensation phase to expect more or less benefit from training at the optimal time point (the maximum of the supercompensation curve) or within the supercompensation window with the ultimate goal to increase the performance potential in the long run.

SUMMARY OF THE INVENTION

[0022] The present invention allows the user to plan the proper timing for setting a next training session on account of the intensity of a training stimulus of a previous session. The invention shows the user when there will have been enough recovery time since the last training session to suggest the best time point and/or time window for starting the next training session. The invention bases the timing recommendations on a supercompensation time curve that depends on a user dependent factor that includes at least the training load of the last training session and preferably also on the training status of the user. Further parameters like age and gender and variables like behavior affecting recovery, as there are for example tiredness from lack of sleep, dehydration from insufficient drinking, insufficient calories, protein, mineral or vitamin intake, consumption of alcohol and other drugs, can additionally be used to influence the recovery timing calculations.

[0023] As described above, devices and methods for estimating the training load are available to a person of ordinary skill in the art based on heart rate monitoring. While the training load, or parameters like training intensity and training time, of which training load can be calculated by integration, could be entered after each training session in a software adopting the inventive method, in a preferred instance of the invention the training load will be measured by at least one sensor. Data detected by the sensor is evaluated and provided as input into software automatically. Sensors useful to measure the training load are known to persons skilled in the art, like heart rate monitors, simple activity monitors for detecting steps, pressure or force sensors, accelerometer based speed and distance monitors (e.g., U.S. Pat. No. 6,301,964B1), more advanced inertial measurement units including gyroscopes, speed and distance monitors based on global navigation systems like GPS. The latter systems can detect changes in height above sea level on a limited accuracy, therefore often air pressure sensors are used to give more accurate information on height changes.

[0024] In a preferred embodiment of the invention the sensor(s) used not only provide information on the amount of training work (time, speed, distance, height changes, calories burnt) but also on the impact of the training on the subject, like heart rate changes, heart rate variability, acidity, lactic acid levels, impacts and/or vibrations (or similar parameters detected by accelerometry), pronation and/or tibia rotation (e.g., U.S. Pat. No. 7,912,672B2), or similar parameters detected by gyroscopes.

[0025] Many studies have addressed the quite high rate of injuries of leisure runners which is found to be between ⅓ and ⅔ of all runners participating in such studies during the study within one season, almost all of them suffering of musculoskeletal pain, with the most prominent areas being the knee and the Achilles heel. The exact causes, however, are still unknown to a great extent (Heiderscheidt J Orthop Sports Phys Ther. 2014 October; 44(10):724-6). Nevertheless, as musculoskeletal injuries are certainly caused by physical stress, physical load measurements on the runners' legs are preferred over heart rate based measurements.

[0026] In a preferred embodiment of the invention measurements correlating to physical stress on the musculoskeletal lower body parts (including ligaments and fascia), like acceleration impacts and/or vibrations, like foot pronation and/or tibia rotation or similar measurements are evaluated. Such measurements are evaluated not only for the amount of physical work done, but alternatively or additionally evaluated to indicate the joint loads, i.e., the accumulation physical stress on the joints, in particular the foot, knee and/or hip. This can be achieved for example by integrating a squared product of the measurements, as individual strong impacts typically have a more than linear impact on tissues.

[0027] Characteristics influencing the joint load, such as the suitability of a user's shoes for the individual running style of the user, the amount of wear of the shoes, the underground structure, and running speed are thereby monitored. The accumulated joint load during a training session or for several training sessions can be used to give a warning feedback (alert) to avoid overload, for example by suggesting to reduce the load. These suggestions could be, for example, to return home when 50% of the individually set load maximum is reached, to reduce speed, or to discontinue high training load. In a preferred embodiment, the individually set load maximum is derived by a standardized training status protocol, as known to persons skilled in the art and which can be facilitated by evaluating the measurements. In a more preferred embodiment, said load maximum is automatically derived and/or adjusted during the training session, e.g., by evaluating measurements for signs of fatigue, like reduced step length or step height, or increased stance time (as fraction of total step time) or decreased impacts or increased pronation velocities or similar evaluations of the measurements.

[0028] In a preferred embodiment the user's subjective evaluation of the training session and the recovery process are recorded by standardized input forms. In particular, any incidences of pain and their strength and persistence are recorded, both during the training session and thereafter, including Delayed Onset Muscle Soreness (DOMS). In case an incidence of pain has been recorded, in the next training session said warning feedback (alert) is adapted to occur at a level below the load level, where the first incidence of pain have occurred. The safety margin, how much below said load level the warning will occur preferably depends on the strength and persistence of the pain.

[0029] In a preferred embodiment many users' successive training loads and training frequency (and thereby recovery timing) are stored together with his or her objective measurements based on sensor evaluation as described above and/or subjective evaluations as just described are stored on a central server and analyzed to gradually improve the calculation methods, calculation parameters and eventually the suggestions to the user based on the current measurement data.

[0030] In a preferred embodiment the system is capable of giving real-time feedback on certain evaluations to allow the user to optimize his or her training, for example to optimize the running style. Parameters which are regarded as important for the running style are for example the step frequency vs. step length, with beginners often taking steps too long instead of raising the step frequency. Similarly in cycling beginners often step too hard (applying too much torque) instead of raising the pedaling frequency. Another parameter important for running style is the kind of foot strike, i.e. heel strike, mid-foot strike or toe strike. Furthermore, the height of the foot during swing time is important, as a higher distance from the ground reduces the length of the leg leverage arm and reduces the necessary energy for swinging the leg upfront. Further important parameters which are considered in running are the outward or inward rotation of the foot at stance, the pronation of the foot during stance and the rotation of the lower leg (tibia rotation).

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] In the drawings, wherein like reference characters denote similar elements throughout the several views:

[0032] FIGS. **1***a* and **1***b* are prior art depictions of a supercompensation curve;

[0033] FIG. **2***a* shows a supercompensation curve with an ascending sigmoid curve and a descending sigmoid curve that added together form the supercompensation curve;

[0034] FIG. **2***b* shows the same supercompensation curve as FIG. **2***a* with as presented to the user;

[0035] FIG. **3** shows a supercompensation curve for a better trained subject, i.e., an athlete;

[0036] FIG. **4** shows a supercompensation curve for the case when the previous training stimulus was weak;

[0037] FIG. **5** shows a supercompensation curve for the case when the previous training stimulus was very strong;

[0038] FIG. **6** shows another supercompensation curve with a short optimal period for a next training session;

[0039] FIG. **7** is a table showing training status;

[0040] FIG. **8** is a table of parameter values for an equation of the supercompensation curve;

[0041] FIG. **9** is a table of parameter values for an equation of the supercompensation curve dependent on diverse training loads

[0042] FIG. **10** is a table showing further calculation factors for a parameter value for the equation of the supercompensation curve dependent on the user's behavior during the recovery process;

[0043] FIG. **11** is a table showing feedback types to the user based on values of the supercompensation curve of FIG. **2**;

[0044] FIG. **12** shows selected sensor signals and filtering of running steps used to obtain time points for calculation;

[0045] FIG. **13***a* shows the peripheral sensor unit (e.g. shoe sensor), FIG. **13***b* the input/output device (e.g. smartphone), FIG. **13***c* the remote server for data storage;

[0046] FIG. **14** is a flow chart according to an embodiment of the invention in use; and

[0047] FIG. **15** is a flow chart according to another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0048] The inventors of the present invention have provided a device for modeling a recovery-supercompensation curve (hereafter referred to as SUPERCOMP), which includes the recovery phase, supercompensation phase, and loss of supercompensation phase, i.e., phases b to d in FIG. **1***a*. The training load phase, i.e., phase a in FIG. **1***a*, is typically on a much shorter time scale and is not of interest for the purpose of guiding the athlete in the recovery and supercompensation training. In a preferred embodiment, the SUPERCOMP curve is a combination of at least two curves, an ascending s-shaped curve (sigmoid) and a second descending s-shaped curve (sigmoid) which is longer in scale and less pronounced in amplitude, as exemplified in FIG. **2***a*. S-shaped, or sigmoid, curves are often used in biology representing growth and saturation effects. If growth of N over time t is $dN/dt=rN*(K-N)/K$, with r being the growth rate and K the carrying capacity, the solution is the sigmoid function $N=K/(1+e^{-r*t+c})$, with the constant c locating the process in time. Besides some scaling factors it is mathematically equivalent to the hyperbolic tangent function (in short TAN H): $1/(1+e^{-t})=\frac{1}{2}*(1+\mathrm{TAN\ H}(t/2))$, which is used in the following for the simpler notation.

[0049] The SUPERCOMP curves in the examples described below are a function of time t with time given in days since the end of the last training session. In one specific embodiment of the present invention, the SUPERCOMP curve is an ascending sigmoid curve, from which a second sigmoid curve (effectively constituting a descending sigmoid curve) is subtracted, as follows:

SUPERCOMP=gain_*a**TAN *H*(time_*a***t*−time_constant_*a*)+offset_*a*−gain_*d**TAN *H*(time_*d***t*−time_constant_*d*)−offset_*d*.

[0050] There are a total of 8 parameters specifying and linking the ascending and descending sigmoid functions, respectively. To keep the calculation model simple, some of them can be fixed at reasonable values, however, some at least are preferred to vary with user dependent values, as described below.

[0051] In the following examples of the invention, of the 8 parameters:

[0052] 4 parameters, time_a, gain_a, offset_a and time_d, vary with user dependent values;

[0053] 2 parameters, gain_d and offset_d vary in a fixed proportional with gain_a;

[0054] 2 parameters, time_constant_a and time_constant_d are set constant.

[0055] The time scale for the descending sigmoid curve is generally longer, for example longer by a factor of 3, in which case time_d is time_a/3. The constants which locates the process in time, time_constant_a and time_constant_d, respectively, are for example 2 days in both cases, meaning 2 days as peak ascending speed and 6 days (because of the time scale factor of 3) as the peak descending speed. The peak ascending speed and the peak descending speeds are the points of maximum slope values, as shown in FIG. **2***a*. The point of the maximum slope values are also the turning points of the ascending and descending sigmoid functions, respectively.

[0056] The scaling factors are for example ¾ for the ascending sigmoid for gain (gain_a) and offset (offset_a), resulting in a raise from 0 to 150% in the example of FIG. **2***a*, and −½ (which is −⅔ of the ascending scaling factor) for the descending sigmoid (gain_d and offset_d) in the example of FIG. **2***a*, which means it drops from 0 to −100%. Added together, the resulting curve will rise above 100% at 2.5 days to a peak of 127% at 3.5 days and falls below 100% at 6 days. The time window between 0 and the raise above the 100% reference line is the recovery phase (0 to 2.5 days in FIG. **2***a*). The time window between the raise of the supercompensation curve above the reference line and the subsequent drop of it below the reference line is the supercompensation phase (2.5 to 6 days in FIG. **2***a*). In case the supercompensation curve does not raise above the reference line, for example when the previous training load was small, the recovery phase is until the peak (maximum) of the supercompensation curve and there is no supercompensation phase (with the ideal timing of the next training as soon as possible after said peak, for practical purposes within a day or two).

[0057] The scaling factors and the resulting values are somewhat arbitrary and chosen for an intuitive representation rather than representing a physiological measurement like the reduction of a performance potential (100% being the performance potential before the last training session, the reference line), which would be a few percent drop only. Scaling factors could be easily adapted to represent such physiological values. The main purpose is the proper combination of the ascending and descending sigmoid functions (i.e., the relative scaling factors of the two sigmoid functions are most important) to retrieve a graph which represents the timing of the supercompensation cycle and derive and visualize helpful timing information and provide a motivational tool for the user for his or her training sessions. Therefore the decay after the supercompensation window is quite strong and for motivational purposes (to stimulate a new training session soon) rather to represent a true rapid loss of performance potential after the end of the supercompensation phase. Scaling factors of the descending sigmoid of ⅓ instead of ⅔ of the ascending sigmoid would result in a never ending supercompensation phase (the curve never dropping from above to below the reference line), failing to visualize the detraining phenomenon as described in the introduction. Therefore preferred scaling factors of the descending sigmoid are more than ⅓ of the ascending sigmoid.

[0058] In a preferred embodiment the recovery-supercompensation curve is visualized to the user in a graphics display. As shown, for example in FIG. **2***b* the user can more readily see how the recovery is predicted to evolve in time, when will be the time window of the supercompensation phase and at which time point to best start the next training session, all at a glance. The curve in FIG. **2***b* is the same as the curve in FIG. **2***a*, but is presented so that the recovery and super-compensation periods are easily discerned by the user. The time scale can name the days of the week for easy scheduling (FIG. **2***b*). The remaining time of recovery to the optimal time point can be calculated and shown, e.g. in a balloon, which preferably moves with time on the recovery-supercompensation curve (FIG. **2***b*). Additional motivational texts can be provided by text or speech messages, examples are given in the table in FIG. **11**.

[0059] In a preferred embodiment the graphical display changes its color with respect to the current status with the recovery-supercompensation cycle. For example, shortly after a training session, when still in the recovery process, dun-colored blue-green colors suggest to the user that he or she should wait to gain more energy, while hot orange colors during the supercompensation phase suggest to the user that he or she is full of energy and should start a new training session soon. Examples for a color coding scheme are given in the table of FIG. **11**. The specific color schemes described are merely examples of the general concept of changing display color to match the different phases of the SUPERCOMP curve.

[0060] In FIG. **2***b* and in FIGS. **3**-**6** the labeling of the y axis below the reference line, is the inverse (**1**—SUPERCOMP) and drawn with an inverted scale, as this represents the training stimulus, one of the parameters to vary with the user's input in a preferred embodiment.

[0061] In a preferred embodiment the parameters vary with the training status of the user since one of the desired training effects is the faster recovery process in better trained subjects. For example, better trained subjects, i.e., athletes, will have a shorter time scales, which results in an optimal training period after 2 to 3 days (FIG. **3**).

[0062] Training status can be obtained by user's input or calculated from measurements recording the training sessions by technically assisted training monitoring systems like heart rate monitoring, location based monitoring (like GPS or local timing infrastructure for triangulation), pressure or force based monitoring, accelerometry based activity monitoring, camera based activity monitoring and/or others monitoring principles. An example of the training status is given in the table of FIG. **7** which simply depends on the weekly amount of training. In a preferred embodiment the intensity of the training is taken into account in addition (e.g. the running speed, the slope). In a preferred embodiment the development of the training status is monitored and corrected appropriately. In a further embodiment an increase in training status is displayed to the user to provide positive feedback for his or her training effort.

[0063] In another embodiment the parameters vary with the training stimulus induced by a training load. The training stimulus is given in a percentage value of the user's individually defined training load level. For example, 100% training load to be the user's normal full training mileage at the aerobic/anaerobic threshold in long distance running. The training stimulus of each training session can be derived by a user's input (subjective value), by a measurement value related to a reference training session (objective value), or a combination of both. Users with a higher training status will need a higher training load to achieve a certain training stimulus. A user giving only a weak training stimulus will have a decreased scaling factor, without or barely reaching a supercompensation level (compare FIG. **4** to FIG. **3**). However, with a weak training stimulus as in FIG. **4** the amount of time necessary for recovery is reduced, thereby allowing a new training session to be started earlier (comparing FIG. **4** to FIG. **3**). Also, the new training session can be harder, have a higher training stimulus, after a weak training stimulus.

[0064] In contrast, a user with an exaggerated or hard training load will expand the recovery time vastly, missing or almost missing the supercompensation effect (FIG. **5**, compare to FIG. **3**).

[0065] In a preferred embodiment, the recovery time will depend on the user's behavior during the recovery period. Negative effects, i.e., recovery delaying factors, are for example tiredness from lack of sleep, dehydration from insufficient drinking, insufficient calories, protein, mineral or vitamin intake, consumption of alcohol and other drugs. Further positive effects for recovery (apart from avoiding negative effects) which can be taken into account are for example massages, walks. A delayed recovery prolongs the ascending time scale without affecting the descending time scale giving the user only a very short optimal period for the next training session (FIG. **6**).

[0066] The parameters for different use cases can be stored in a table as exemplified in FIG. **8** and the most appropriate taken for a specific situation.

[0067] More detailed tables can be stored as exemplified in FIG. **9** for the effect of training stimulus on the parameters and the most appropriate taken for a specific situation. Even more details can be obtained by interpolating between table entries. The choice for the parameters can be calculated on a user's input of his or her training performed or calculated from measurements recording the training sessions by technically assisted training monitoring systems like heart rate monitoring, location based monitoring (like GPS or local timing infrastructure for triangulation), pressure or force based monitoring, accelerometry based activity monitoring, camera based activity monitoring and/or others monitoring principles.

[0068] Training stimulus can raise above 100%, if one is performing an unusual hard training session.

[0069] In a preferred embodiment the parameters' variation with training status, training stimulus and other factors are calculated by specific formulas.

[0070] In a specific example given below, training stimuli below 50% and above 50% have different calculation formulas.

Example Calculation of Parameters for Training Stimuli Below 50% (Very Weak Training Stimulus)

[0071]

$$time\_a=-1*(training\_status+2.5)*training\_stimulus+0.8(training\_status+2.5)$$

$$time\_d=training\_status/15$$

$$gain\_a=training\_stimulus/2$$

$$offset\_a=1-gain\_a$$

Example Calculation of Parameters for Training Loads Above 50%

[0072]

$$time\_a=(0.24*training\_status+0.6)*(1-\mathrm{TAN}\,H(1.6*(training\_stimulus-0.5)))+0.08*training\_status$$

$$time\_d=training\_status/15$$

$$gain\_a=training\_stimulus-0.25$$

$$offset\_a=0.75(constant)$$

[0073] In a preferred embodiment parameters like time_a can be further individualized by manual input of recovery influencing behaviors (as listed above) and/or reported injuries. As an example the user is given a 7 point scale to self-qualify on his or her recovery process. Based on this settings a correction factor for time_a is taken, which is multiplied to the previously calculated time_a (see FIG. **10**).

[0074] Alternatively, each of the individual recovery measurements could be asked for separately and a resulting correction factor calculated from multiplying the individual correction factors, each of them for example ranging between 0.85 and 1.05. Negative influences have a stronger weight than positive influences, so that even more than one positive influence cannot make up for one strong negative influence.

[0075] In a preferred embodiment recovery influencing behavior is in addition to or alternatively to manual input automatically retrieved by behavior monitoring systems, such as for example fitness monitors, sleep trackers, systems recognizing the activity of daily living (ADL), systems measuring the hydration status or other monitoring systems.

[0076] In a preferred embodiment the recovery process is monitored for example by systems monitoring heart rate changes, heart rate variability, redox status or components involved in ROS (reactive oxygen species) signaling.

[0077] In a preferred embodiment parameters like training_status can be further individualized for a personal trainability correction factor that takes into account gender and/or age of the person. For motivational reasons, reported training_status is not changed but corrected with a personal trainability correction factor.

[0078] The correction factor can simply be calculated from chronological age above a certain age, for example by the formula 1−((age[years]−constant)/scale), with the constant parameter for example being 25, as at this age the trainability is at the highest point and the scale parameter for example being 100 to fit the age over 25 to the scale of the training_status. A person with 55 years of age would therefore result in a correction factor of 1−((55−25)/100)=0.7, which is multiplied with the training_status as found above by the activity level, whether by manual input or found automatically with the help of sensors.

[0079] In a preferred embodiment the evaluations of the training sessions of multiple users are stored in a central database which resides on a remote server and used to improve calculation parameters. For example, the correction factor for age as given above might be found to be too low (the difference between younger and older athletes actually still higher) or too high (the difference between younger and older athletes actually not as high), and subsequently changed to values better fitting the data of many comparable users, or many users over a several year's period of time.

[0080] For another example a possible gender difference is analyzed. Though it is known that men and women have a difference in trainability, it is not known to our knowledge whether there is a difference in the time course of the recovery process. Therefore the specific formulas disclosed do not have a gender difference. However, by analyzing many training sessions of many users, of both men and women, the data might reveal differences, for example that women have a slightly slower time course than men, in which case the timing parameters, e.g. time_a, would be slightly lowered for women.

[0081] In case of two consecutive trainings in short time interval, when the recovery phase of the first training session was not over yet, i.e. when the SUPERCOMP calculation did not cross the reference line yet, the remaining value at the start of the second training session is in a preferred embodiment added to the training stimulus revealed by the work load of the second training session. For example if the recovery process after the first training is calculated as shown in FIG. **6** and the second training session already started after 2 days, the value at this time point, approximately 40%, is added to the training stimulus of the second training session. In case this is 100%, the resulting sum of 140% is used for the calculation of the recovery-supercompensation curve of the second training session, leading to a result as shown in FIG. **5** rather than in FIG. **3**, effectively carrying over another day for recovery in this example.

[0082] However, even if the suggested recovery periods are all met in several consecutive training sessions, there is still some carry over to consider. As described in the introductory part, there are various physiological recovery processes with different time courses going on after exercising thus periodization of training with tapering phases is commonly planned by athletes and trainers. Therefore another very useful example of evaluating a multitude of training sessions from multiple users is to reveal proper carry over parameters for timely scheduled consecutive training sessions.

[0083] In a preferred embodiment the training status is automatically adapted by evaluating measurements for signs of fatigue, as described above. As a specific example the calculation of the stance time (as fraction of total step time) is used. While the total step time is fairly easy to measure with accelerometers since the impact is very pronounced, the end of the stance phase, the toe-off event, is very difficult to detect with accelerometers. Therefore the readings of a gyroscope of the sagittal plane (Gyro-SP, around the left-right axis) are preferred. A simple IIR low-pass filtered signal of said gyroscope readout by use of: $y(n)=\alpha*x(n)+(1-\alpha)*y(n-1)$, where of the current reading x(n) only the small fraction a is taken and added to previous calculation output diminished by the same small fraction a, is used, which, on the proper choice of a, which is found to be 4/f, f being the recording frequency in Hz, gives a phase shift of the right amount to have the maximum of the filtered signal to coincide with the toe-off event. This is the case for both walking and running (for the same value of α) and can therefore be used to distinguish between those two. In fact the comparison of the duration of the stance phase (time of impact to time of toe-off) to the duration of the swing phase (time of toe-off to time of next impact) is exactly the definition of distinguishing between walking (longer stance phase) and running (longer swing phase), so this simple memory saving filter can be used to distinguish between running and walking steps. An example of two consecutive running steps is shown in FIG. **12**.

[0084] In a preferred embodiment the system is giving real-time feedback on certain evaluations to allow the user to optimize his or her training as described above. As a specific example the feedback to train optimal step frequency is provided. Actual step time is measured by the time difference of two consecutive impacts, as detected by an accelerometer and/or a gyroscope (see FIG. **12**). Step length is calculated by calculating orientation in space by fusing 3-axis accelerometer and 3-axis gyroscope data with or without 3-axis magnetometer, as known by persons skilled in the art. Once the orientation in space is known, the vector of earth gravity can be subtracted from the accelerometer signal. The remaining accelerometer signals are integrated with setting zero speed at mid stance phase and any integration drift is subtracted. The drift corrected speed in direction of running is then integrated once more to provide step length. Individual correction factors might be obtained by a reference test of running a known distance. The optimal step time can for example be calculated as 120−9*step_length [m]/(230−0.5*body_height [cm]). Alternatively to the body height the leg length might be taken, if known to the user, with a different multiplication factor (e.g. 1.1). The actual step time is set in relation to the optimal step time, which according to the above formula, depends on step length and body height (or leg length). The amount of deviation is given as feedback to the user, which feedback can be visual, acoustic or vibrational, or a combination thereof.

[0085] FIGS. **13***a*, **13***b* and **13***c* are block diagrams of a sensor unit **100**, an input/output unit **200**, and a remote server **300** according to an embodiment of the invention. The sensor unit **100** includes a processor **102** and sensors **104**. Although two sensor are shown, the actual number of sensors may be one or more as required. The sensors **104**, as discussed above, can include at least one of a heart rate monitor, activity monitors for detecting steps, pressure or force based monitors, accelerometer based speed and distance monitors, impact and vibration detectors (especially for pronation and tibia rotation), gyroscopes, and speed and distance monitors based on navigation systems like GPS. The sensor unit **100** includes a local wireless transceiver **110** as is known in the art, i.e., Bluetooth or some other known or hereafter developed wireless connection for communication with the input/output unit **200**, as discussed in more detail below. The sensor unit **100** further includes a storage **106** for storing data during a training session and optionally a feedback actuator **108** to provide feedback to the user during the training session. The sensor unit **100** is a small device that is mounted on the user, i.e. on a leg or foot of a runner, or on an exercise machine, i.e., on the crank or pedal of a bicycle, to sense and save data related to a training session of the user.

[0086] The input/output unit **200**, for example a smartphone, includes a processor **202**, a storage device **204**, an input device **206**, a display **208**, a local wireless transceiver **210**, and a feedback actuator **212**. The input/output unit **200** communicates with the sensor unit **100** to receive the data stored during the training session, or for multiple training sessions. The data can be downloaded during the training session if the input/output unit **200** is in communication with the sensor unit **100**. If the input/output unit **200** is not carried by the user during the training session, the download can occur after the training session when the sensor unit **100** is in communication with the input/output unit **200**. For example, a runner may wish to minimize what is carried during a training session and may not carry the input/output device **200**.

[0087] The feedback actuators **108** and **212** provide some signal such as a vibration, audible, or optical signal that a value of one or more parameter is exceeded or falls short. The parameters may include frequency or step length or foot strike for running, or torque for cycling. Other parameters may include foot height during swing time, rotation of foot at stance, pronation of foot during stance, and tibia rotation. The signal provided by the feedback actuators **108** and **212** can serve as the warning feedback or alert discussed above to avoid overload.

[0088] Based on the equation for SUPERCOMP described above, the processor **202** determines an optimal time for the next training session and presents the optimal time to a user on the display **208**. The user is presented with the most optimal time, which is the time of the high point of the SUPERCOMP curve. As an alternative, or additionally, the user could also be presented with a time frame in which the curve is in the supercompensation zone. In a preferred embodiment the supercompensation curve based on the equation for SUPERCOMP described above is shown in a graphics display, therefore the user can see how the recovery is predicted to evolve in time, when will be the time window of the supercompensation phase and at which time point to best start the next training session, all at a glance. The remaining time of recovery to the baseline and/or to the optimal time point can be calculated and shown.

[0089] Although the input/output unit **200** is described as a smartphone, the input/output unit may be a standalone device dedicated to the task of determining a timing of the next training session. Alternatively, the device may be a tablet, computer, or other device that includes other functions. The remote server **300** includes a data storage **302** and a processor **304**. The data storage **302** receives and stores data from a plurality of users. The remote server **300** has a wide area network connection **306** and the input/output device **200** includes a wide area network connection **214**.

[0090] FIG. **14** is a flow diagram of a method according to an embodiment of the invention. When the method is started it is first determined whether the user is new, step **410**. If the user is determined to be new in step **410**, user parameters are input to the input/output unit **200**, step **412**. The user parameters include, for example, training status, age and gender of user. The user then performs the first training session, step **414**. During the training session, the sensor unit **100** records sensor data, step **416**. The user inputs subjective evaluation data, step **418**, such as, for example, incidences of pain during the training session, the levels of strength and persistence felt by the user during the training session, and behaviors affecting recovery. Although steps **416** and **418** are shown in parallel, step **418** can be performed after step **416**. As a further alternative, only one of steps **416** and **418** might be used in certain instances.

[0091] The data recorded by the server unit **100** is then evaluated by the input/output unit **200** with the user parameters and subjective evaluation data, step **420**. The input/output unit **200** then sets personal parameters based on the collected data, step **422**, and calculates a recovery-compensation curve using the personal parameters and displays the calculated recovery-compensation curve in the manner described above to the user, step **424**.

[0092] If the user is not new in step **410**, a next training session is started, step **510**. The input/output unit **200** determines whether the recovery phase of the previous training session is over in step **512**. If the recovery phase is not over, i.e., if the user is still in the recovery phase, the user is issued a warning against overtraining on the input/output unit **200**, step **513**. The user can then wait until the recovery period is over or start the next training session. If the recovery phase is determined to be over, a next training session is started, step **514**. Steps **516**, **518** and **520** are the same as steps **416**, **418** and **420** described above. While recording the sensor data, a check is performed to determine whether a load level value is reached, step **526**. If it is determined that the load level is reached, step **528**, a warning is provided to the user by the feedback actuator or the display to warn against overload, step **530**. After step **520**, the input/output unit **200** updates the user parameter based on the data from the training session, step **522**, and calculates and displays the recovery-compensation curve to the user, step **524**.

[0093] According to a further embodiment shown in FIG. **15**, the results of evaluations of training sessions for a plurality of users are uploaded to a remote server database **600**. In this way, the training sessions of the plurality of users can be evaluated, step **602**. Based on the evaluation, the formulas, formula parameters and/or correction factors of the formula parameters can be fine-tuned, for example, for age, gender, step **604**. Based on the fine-tuning, the various individual parameters can be updated, step **606**.

[0094] Thus, while there have been shown and described and pointed out fundamental novel features of the invention as applied to a preferred embodiment thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated and described, and in their operation, may be made by those skilled in the art without departing from the scope of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Moreover, it should be recognized that structures and/or elements and/or method steps shown and/or described in connection with any disclosed form or embodiment of the invention may be incorporated in any other disclosed or described or suggested form or embodiment as a general matter of design choice. It is the intention therefore, to be limited only by the scope of the claims appended hereto.

1. A training device for determining a timing for a next training session, comprising:

an input device receiving an indication of a user dependent factor, the input device being at least one of a user input device and a sensor unit that monitors an activity of the user; and a processor that defines a time to perform the next training session, the processor uses an equation that estimates at least a portion of a supercompensation curve, the equation being a function of at least one parameter that is varied by the processor based on the user dependent factor.

2. The training device of claim **1**, further comprising a storage device that stores values of the at least one parameter for at least two different values of the user dependent factor.

3. The training device of claim **1**, wherein the user dependent factor is a training load of the previous training session based on a measurement by the sensor unit.

4. The training device of claim **3**, wherein the user dependent factor also includes a training status of the user.

5. The training device of claim **3**, wherein the user dependent factor also includes at least one of age and gender of the user.

6. The training device of claim **3**, wherein the user dependent factor also includes a further variable affecting recovery selected from the group including tiredness from a lack of sleep, dehydration from insufficient drinking, insufficient calories, protein, mineral, or vitamin intake, consumption of alcohol or drugs.

7. The training device of claim **1**, wherein the user dependent factor also includes whether the user took a walk after the last training session, a diet of the user after the last training session, and whether the user had a massage after the last training session.

8. The training device of claim **1**, wherein the input device includes the sensor unit, and the sensor unit measures at least one of acceleration impacts and vibrations correlating to physical stress.

9. The training device of claim **8**, wherein the at least one of acceleration impacts and vibrations correlate to physical stress on a runner's legs.

10. The training device of claim **8**, wherein the at least one of acceleration impacts and vibrations correlate to at least one of foot pronation and tibia rotation.

11. The training device of claim **1**, wherein the equation is a combination of an ascending sigmoid curve equation and a descending sigmoid curve equation, and defines a section of the supercompensation curve.

12. The training device of claim **1**, wherein the supercompensation curve is defined by subtracting a descending sigmoid curve from an ascending sigmoid curve.

13. The training device of claim **11**, wherein the ascending sigmoid curve is defined as gain_a*TAN H(time_a*t−time_constant_a)+offset_a and the descending sigmoid curve is defined as gain_d*TAN H(time_d*t−time_constant_d)+offset_d, wherein TAN H is a hyperbolic tangent function, gain_a, time_a, time_constant_a, offset_a, gain_d, time_d, time_constant_d, and offset_d are parameters and t is an elapsed time after the last training session.

14. The training device of claim **13**, wherein gain_a, time_a, offset_a, and time_d vary based on the user dependent factor, gain_d and offset_d are proportional to gain_a, and time_constant_a and time_constant_d are constants.

15. The training device of claim **11**, further comprising a storage device that stores values of gain_a, time_a, offset_a, and time_d for at least two different values of the user dependent factor.

16. The training device of claim **1**, further comprising an output device that outputs the timing for a next training session to the user.

17. The training device of claim **16**, wherein the timing for the next training session is output as the time associated with the highest point on the supercompensation curve.

18. The training device of claim **16**, wherein the timing for the next training session is output as the time period associated with a supercompensation section of the supercompensation curve.

19. The training device of claim **1**, further comprising a remote server with a storage device storing data for a plurality of users.

20. A method for determining timing of a next training session, comprising the steps of:

obtaining data indicating a training load of a training session of a user by at least one of sensing the data using a sensor unit or receiving the data by user input using an input/output unit;

setting, by the input/output unit, parameters of an equation that estimates at least a portion of a recovery-supercompensation curve based on the data; and

calculating and displaying the recovery-supercompensation curve to the user on a display of the input/output unit.

21. The method of claim **20**, further comprising the step of inputting a user's subjective evaluation of the training session, and said step of setting parameters uses the user's subjective evaluation.

22. The method of claim **20**, further comprising the step of determining whether the user is in a recovery phase of a previous training session.

23. The method of claim **20**, wherein the data sensed by the sensor unit is monitored during the training session to determine whether the data indicates a load level is exceeded.

24. The method of claim **20**, wherein data from a plurality of users is stored in a database, and the parameters of each of the plurality of users is updated based on the collective data.

25. The method of claim **20**, wherein the equation is a combination of an ascending sigmoid curve equation and a descending sigmoid curve equation, and defines a section of the supercompensation curve.

26. The method of claim **25**, wherein the ascending sigmoid curve is defined as gain_a*TAN H(time_a*t−time_constant_a)+offset_a and the descending sigmoid curve is defined as gain_d*TAN H(time_d*t−time_constant_d)+offset_d, wherein TAN H is a hyperbolic tangent function, gain_a, time_a, time_constant_a, offset_a, gain_d, time_d, time_constant_d, and offset_d are parameters and t is an elapsed time after the last training session.

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