
Patented Lifepulse™ System

Heart Rate

A heart rate is typically a measure of the number of times the heart beats in one minute and is usually referred to as the beat-per-minute rate or simply BPM. Every time the heart muscle beats a small electrical signal is generated. The measurement of this signal is called an Electrocardiogram or ECG (also called an EKG in Europe).

The Lifepulse™ System

I. Overview:

Lifepulse™ system uses complex software algorithms which require a microprocessor capable of performing digital signal processing (DSP) functions. The term digital signal processing, or DSP, refers to the process of digitally sampling a signal, converting the sampled signal into a stream of numeric values, then processing these numbers using mathematical techniques to bring out features of the signal not otherwise observable. Lifepulse™ uses DSP techniques to perform filtering and frequency analysis to calculate the heart rate. And, because DSP algorithms operate on a stream of data enough data must be collected before the analysis can be started. Depending upon the noise and signal level a Lifepulse™ value can be displayed in as little as 4 seconds. Generally speaking, the longer you hold the Lifepulse™ sensors the more accurate the results.

II. Step By Step:

The patented Lifepulse™ system features digital processing technology. The Lifepulse™ system digitizes the raw ECG signal and then processes it using a DSP (digital signal processor) microchip. For added reliability, The Lifepulse™ software uses two detection methods a patented *Arbitrator* to ensure accurate HR readings.

PEAK DETECTION METHOD: Locates the strongest signals in the data stream and determines the time intervals between them to produce a heart rate. Requires 4-5 seconds minimum to sample enough data. Note that a 60 BPM rate contains at most 1 beat per second and that in 4-5 seconds there are only 4-5 pulses to be processed. Lifepulse™ looks for an agreement among the time intervals between pulses to determine the most regular occurring rate. Sometimes more time is necessary to allow for more of an agreement to be achieved. Assumes heart pulse is predominant peak. Can be fooled by whatever is strongest repetitive signal (artifacts or noise). Used to quickly report initial heart rate to the user as well as input to arbitrator.

AUTOCORRELATION DETECTION METHOD: Uses a statistical method to identify repetitive signals within a data sample. Requires at least 6-8 seconds minimum to sample data. Could be longer if noise level is too high or heart signal is erratic. Reports frequencies and energy levels of repetitive signals. Heart rate is determined from autocorrelation data based on factors such as signal regularity, energy level, harmonic content, and autocorrelation signal to noise ratio.

The patented ARBITRATOR is a software function which examines the agreement between peak and autocorrelated heart rates as well as trends in the previously reported heart rates, changes in effort level, and speed of exercise (step rate) and determines which method is accurate. The Arbitrator also provides a confidence value used in the Cardio programs, which enable exercise adjustments to reach your target heart rate.



Lifepulse™ Performance

Some factors that may affect Lifepulse™ performance include:

Physiological factors

- Medication – Some medication can lower resting heart rate values below the minimum reported by Lifepulse™ system.
- Cardiac Disease – Cardiac damage affecting the ECG signal may not allow Lifepulse™ to accurately or reliably compute a heart rate.
- Hand Size – Maximum amount of contact between the surfaces of the hands and the sensors allow for a good ECG signal path.

Usage Factors

- Hand placement – Both hands must be placed on the sensors in the correct way to receive the best possible signal. Thumbs should wrap around to close the grip on the sensors with palms and fingers in maximum possible contact at all times.
- Grip pressure – The amount of pressure used to grip the Lifepulse™ sensors has an effect on the quality of the signal. Both sensors should be held with the same grip strength avoiding loose or excessive pressure. Hands must not be allowed to slip or move during Lifepulse™ readings.
- Upper body activity (muscle noise) – Movement in the upper body and arms during the exercise can degrade the ECG signal. For best results on these products minimize shoulder, back, arm, and wrist movements during Lifepulse™ readings.
- Hand & Sensor Contamination – Dirt on hands, excessive dry skin or callused hands, body creams, moisturizers, or lotions on hands, and, dried sweat on the hand sensors should be avoided.

Electromagnetic Interference Factors

- Portable Electronics – Devices that have local oscillators, high frequency signals needed to drive or convert other signals, can interfere with Lifepulse™. Locate these devices away from the Lifepulse™ sensors or the electronic display console.
- Pacemakers – The pacemaker generates electrical signals which may overwhelm the Lifepulse™ input amplifier possibly resulting in measurement errors or the inability to obtain a measurement. In the worst case, the pacemaker's electrical signals may damage the Lifepulse™ input circuit. Consult with your doctor about using the Lifepulse™ contact heart rate system if you have a pacemaker.
- Appliances – Certain electrical appliances, capable of generating broadband RF noise, may interfere with the Lifepulse™ signal. Locate these appliances away from Lifepulse™ equipped products.
- Motor Drive Systems and other power devices – Avoid placement near products which do not limit or filter radiated or conducted electrical energy. All Life Fitness products are designed with appropriate filtering and shielding of high frequencies. These systems need to always be maintained properly and according to the manufacturer's specifications.

Quick Points



- In order for Lifepulse™ to begin reading the ECG signal it must first recognize that someone is holding the sensors. If and only if, both hands are in good contact with their respective sensors will Lifepulse™ begin to sample the ECG signal.
- The minimum heart rate value displayed is 50 BPM. The maximum heart rate value displayed is 200 BPM. Heart rate values outside of these ranges will not be reported; instead no heart rate reading will be displayed.
- It takes 5-10 seconds (5-15 seconds on the stairclimber and treadmill products) to collect enough data to analyze and compute an accurate heart rate for most people. The more data received (i.e., the longer the sensors are held) the better the system works.
- It is recommended to limit upper body motion when attempting a Lifepulse reading.
- The use of Lifepulse™ is not recommended after 5mph on Life Fitness treadmills.
- If you are having problems, temporarily stop exercising and try to obtain your Lifepulse™ reading.
- Lifepulse™ system is not and cannot be used as a medical diagnostic device.
- When comparing a Lifepulse™ reading to a manual heart rate reading (pulse count method), it is best to stop exercising and immediately take a 6-second pulse count. The accuracy between the readings may be different by as much as ± 13 beats per minute due to the inaccuracy of the pulse count method at ± 10 BPM in a 6-second reading, and the inaccuracy of Lifepulse™ at ± 3 BPM. While longer pulse count measurements improve the manual heart rate accuracy it makes the last Lifepulse™ reading too old for an accurate comparison (you cannot do both simultaneously).

Competitive Hand Sensor Heart Rate Systems

Competitive systems like TechnoGym, Star Trac, etc., use a digitized peak detect system to determine a HR value. These systems have no way of knowing which muscle is firing. It gathers analog information, digitizes it, and publishes what it thinks is the heart rate. Because it does not extract non-heart rate muscle firings the published heart rate could be off as much as 10 to 20 beats or more. This is potentially dangerous for people who select their workout based upon heart rate monitoring.