

## Serene™ breathing exercise

Research and Technology

December 12, 2019

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### 1 Introduction

Occasional mental stress is a part of everyday life. Stress can come from different sources, such as work, family duties, or training and competitions. Optimal sports performance demands the ability to cope with mental stress and pressure. Mental stress can also significantly increase the risk of injury in athletes, and thus reduce participation in training.<sup>1</sup> Besides, learning to cope with stressful situations is crucial to our health. Chronic stress can lead to various health problems including, for instance, heart problems, high blood pressure, diabetes, anxiety, and insomnia.<sup>2</sup>

Different relaxation strategies offer tools for stress management. The strategies may be used to increase concentration, promote relaxation, and reduce stress. One of the scientifically studied strategies is slow deep breathing, also called diaphragmatic breathing, abdominal breathing, or

just belly breathing. Biofeedback is one form of performing a breathing exercise. It helps an individual learn to control physiological responses by displaying in the real time how his/her breathing affects measured physiological parameters.<sup>3</sup>

Many studies have reported on the benefits of deep and slow breathing. Intervention studies demonstrate that deep breathing is associated with reduced anxiety and stress, improved cardiovascular and autonomic function, improved sleep, and reduced pain.<sup>4,5,6,7</sup> Studies of meditation, including focused breathing, suggest also a possible benefit regarding cardiovascular risk.<sup>8</sup> These findings support the idea that regular practicing of deep breathing helps reduce cumulative effects of stress in the body. Furthermore, studies in athletes, although still sparse, suggest that deep breathing with biofeedback is an effective, safe, and easy tool for both athletes and coaches to improve sports performance.<sup>9</sup>

This paper describes Polar's Serene™ breathing exercise, an easy tool for relaxing the body and mind. Serene utilizes guided deep breathing and real-time biofeedback in order to increase an individual's awareness of and control over physiological responses related to stress and relaxation. Serene™ breathing exercise is developed by Polar, and the patent publication EP3534373A3 is related to the feature.

### 2 Background

Breathing exercises typically elicit the relaxation response in the body, which is an antidote to the stress response. Slow and deep breathing makes breathing-related variation in the heart's beat-to-beat intervals to grow many times and be closely in sync with breathing rate.

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### 2.1 Relaxation response

Events or circumstances that an individual perceives as threats trigger the stress response that makes an individual ready to mobilize energy ready for "fight or flight". The stress response involves the brain, a series of stress hormones, and the autonomic nervous system.<sup>10</sup> Physiological changes include, for instance, increases in heart rate, breathing rate, and blood pressure as well as the redistribution of blood flow. More than 30 years ago, cardiologist Herbert Benson characterized the relaxation response, the opposite bodily reaction to the stress response.<sup>11</sup> An individual can intentionally evoke the relaxation response with various strategies, including breathing exercises. The relaxation response is associated with decreases in oxygen consumption, respiratory rate, and blood pressure, along with an increased sense of well-being.

One pathway by which deep and slow breathing offsets the stress response is adjusting autonomic control. The autonomic nervous system consists of two branches with opposite effects. The sympathetic nervous system facilitates behavioral activation in response to perceived stress. The parasympathetic nervous system is responsible for energy conservation and restoration. Practising of deep breathing has been reported to improve autonomic control at rest as well as reduce autonomic reactivity to stress.<sup>e.g.4,7,12</sup>

### 2.2 Respiratory sinus arrhythmia

Breathing is one of the several mechanisms behind heart rate variability (HRV), i.e. variation in the time between successive heart beats. The term respiratory sinus arrhythmia refers to variation in the heart's beat-to-beat intervals that occur during each breathing cycle: beat-to-beat intervals shorten during inhale and lengthen during exhale.<sup>13,14</sup> In other words, heart rate speeds up with inhale and slows down with exhale.

Amplitude of HRV is related to breathing rate. HRV amplitudes are higher at slower breathing rates, breathing at a rate of 6 breaths per minute producing the highest amplitude of HRV.<sup>13,15</sup> During slow and deep breathing, the amplitude of HRV typically grows to many times the amplitude at rest with normal breathing, while the pattern of HRV becomes simple and sinusoidal.<sup>16</sup> Figure 1 illustrates an instant change in HRV in response to deep and slow breathing. Mechanisms behind the HRV pattern characteristics to deep and slow breathing (6 breaths/min) is considered to include: phase relationships between HRV and breathing, phase relationships between heart rate and blood pressure, activity of baroreflex, and resonance characteristics of the cardiovascular system.<sup>16</sup>

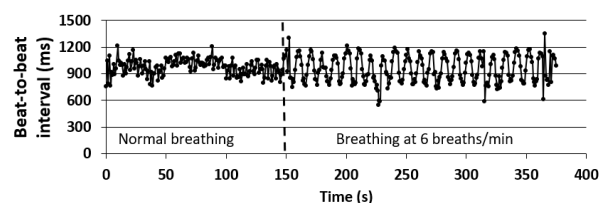


Figure 1. An example of the heart's beat-to-beat intervals as a function of time at rest with normal breathing and with breathing at a rhythm of 6 breaths per minute. Slow guided breathing with an even rhythm increases the amplitude of HRV and makes the pattern of HRV sine-wave-like.

## 3 Validity

Serene breathing exercise is based on up-to date scientific knowledge of breathing practices used for relaxation and stress management. Its elements and feedback algorithm have been carefully tested and validated in Polar's internal studies. For instance, the effects of different breathing guidance on the physiological response have been studied in several experimental designs. Moreover, it has been stated that Polar optical beat-to-beat interval measurement is accurate enough at rest when the user does not move his/her hand.

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### 4 Serene breathing exercise

The Serene breathing exercise is a stress management tool that helps the user to relax his/her body and mind. Serene guides the user to breath slowly and deeply in order to elicit the relaxation response. During the exercise session, the user gets biofeedback on his/her bodily response. Real-time analysis of the heart's beat-to-beat intervals is a key to giving biofeedback. After the session, the user gets a breakdown of his/her overall success. The feedback considers how well in sync the user's HRV is with his/her breathing and how close his/her breathing rate is to the optimal breathing rate.

#### 4.1 Benefits

The Serene breathing exercise provides the following benefits:

- The user can relax his/her body and calm down his/her mind anytime and anywhere
- During a breathing exercise session, the user gets real-time guidance for proper breathing rate and biofeedback on his/her body's response
- After the session, the user gets a breakdown of how well (s)he succeeded in eliciting the bodily relaxation response.
- With consistent use, Serene can help the user manage stress and promote well-being and cardiovascular health

#### 4.2 Guidance

Learning to breathe deeply by engaging the diaphragm is important for eliciting the relaxation response. Therefore, Polar provides tutorials on the correct breathing technique. The diaphragm is a dome-shaped muscle located just below the lungs separating the chest from the abdomen. It is the single most important muscle engaged in breathing. During each inhale, the diaphragm drops downwards, making room for the lungs to

expand as their fill with air. During each exhale, the diaphragm relaxes, and the natural elasticity of the rib cage pushes the air out of the lungs.

Once the user is familiar with the breathing technique, (s)he can move on to Serene breathing exercise. Serene provides subtle visual and haptic guidance, and thus, it can be done in virtually anytime and anywhere. However, a quiet place where the user can sit or lie down comfortably helps relax better. It is important to keep the hand still throughout the breathing exercise to enable the accurate optical measurement of the heart's beat-to-beat intervals.

Not only breathing rate but also the ratio between inhale and exhale durations has been shown to affect HRV magnitude and feelings of relaxation. <sup>e.g.<sup>17</sup></sup> Therefore, Serene breathing exercise allows the user to personalize the breathing guidance so that (s)he feels it pleasant. The user can choose the duration of the session and the inhale and exhale timing. Inhale and exhale durations can be selected within certain limits, resulting in breathing rate to be between 5 and 10 breaths per minute. Exhale duration is always the same as inhale duration or longer. It has been suggested that a breathing pattern, where exhale duration is longer than inhale duration, brings the best benefits of slow breathing.<sup>17</sup> Serene is designed for a continuous flow of air in and out, and it is not possible to set a time for holding breath after inhale or exhale.

#### 4.3 Feedback

While breathing with Serene, the user gets real-time biofeedback, and after the exercise session, (s)he gets the breakdown of his/her success. Serene feedback algorithm calculates how homogeneous sine-wave-like the HRV signal is. In addition, it considers how close the user's breathing rate is to the optimal breathing rate of 6 breaths per minute. In short, the heart's beat-to-beat intervals are measured from a wrist with

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photoplethysmography. It is an optical technique that detects pressure pulses traveling through blood vessels. Then, spectral analysis is used to analyze HRV (or to be precise pulse rate variability). The analysis reveals what is the dominant frequency of the signal and how sine-wave-like the signal is. Figure 2 shows two examples of HRV with breathing at a rhythm of 6 breaths per minute.

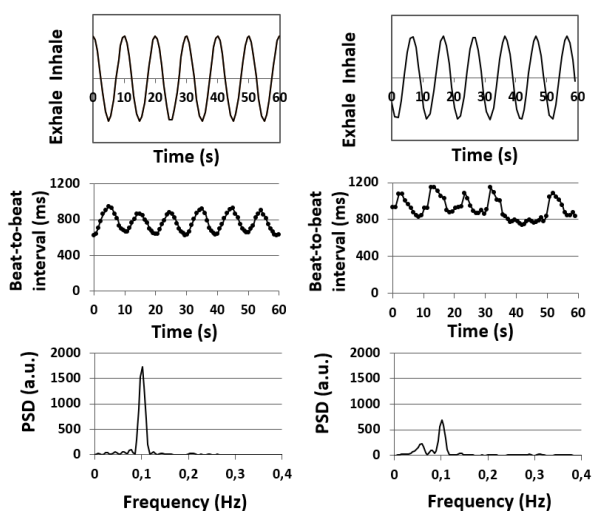


Figure 2. An example of optimal (on the left) and good (on the right) synchrony between the heart's beat-to-beat intervals and breathing rate. The top panels show breathing guidance with a rhythm of 6 breaths per minute. The middle panels show the heart's beat-to-beat intervals. The bottom panels show power spectral density (PSD) of the beat-to-beat intervals.

The results are communicated to the user as Serenity zones. The zones are Diamond (optimal), Sapphire (very good) and Amethyst (good). The higher the zone, the better the synchronization between HRV and the optimal breathing rate is. For the highest serenity zone, Diamond, the user needs to be able to sustain the slow target rhythm of around 6 breaths per minute, or slower.

During the exercise session, the current Serenity zone is visualized to the user. After the session, the user gets a summary of the time (s)he spent in the three Serenity zones. The more time the user spent in the higher zones, the more benefits (s)he can expect to feel in the long term. Figure 3 illustrates how time in the three zones accumulates during the exercise session.

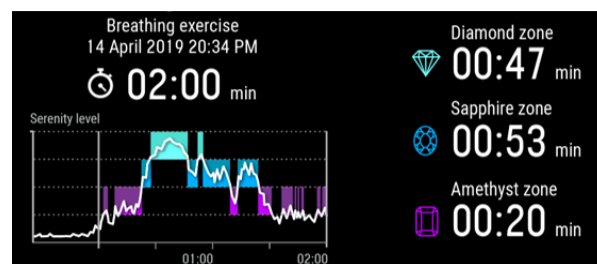


Figure 3. An illustration of the logic behind of Serenity zones. During each session, Serenity level (curve) is calculated. At the end of each session, the feature shows the time spent on the three Serenity zones: Diamond (optimal), Sapphire (very good) and Amethyst (good).

### 4.4 Recommendations

To achieve the full benefits of deep breathing it is recommended to practice the Serene breathing exercise regularly. One good choice is to reserve time for the exercise at about the same time every day. It may help the user to establish a new routine. Initially, 5 to 10 minutes per day is a reasonable goal. If the user aims at getting the most out of Serene, (s)he can increase exercise duration up to 20 min. However, it is good to keep in mind that any time spent breathing deeply and relaxing is better for the mind and body than none.

### 5 Limitations

In general, there are some limitations in performing breathing exercises. Slowing breathing to a rate of six breaths per minute may inappropriately make some people breathe very deeply. Overbreathing is typical for beginners, and it may cause such problems as dizziness and discomfort. In addition,

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respiratory tract infections may make guided slow breathing uncomfortable. Furthermore, as with any breathing exercise, Serene provides mainly short-term relief from stress symptoms. Serene works best when it is combined with other tools for stress management.

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