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Breathe

Psychological stress is important to handle for multiple reasons. One important reason is that stress has been found to be a contributing factor to a number of both physiological and psychological diseases and disorders, like cancer, cardiovascular disease, depression and anxiety. Our emotional state has a great impact on our physiological system through, for instance, the nervous system and immune system (Perciavalle, et al., 2017), but this is also the case the other way around: The relationship between certain psychological disorders like stress, depression and anxiety and physiological disorders cardiovascular disease, for instance, is bi-directional: stress, depression and anxiety increases the risk of getting a cardiovascular disease and vice versa (Chaddha, 2015). A widely used strategy for reducing both psychological and physiological symptoms associated with stress is the voluntary modification of breathing patterns. Focus on our breathing can, amongst others, help maintain focus on internal sensations instead of external stimuli, while breathing patterns physiologically can affect the nervous system (Van Diest, et al., 2014).

The nervous system

The nervous system has a profound effect on our general functioning; both in terms of physiological and psychological well-being. When studying the relationship between breathing patterns and stress as well as the effects of breathing seen in isolation, the interesting part of the nervous system is the autonomic nervous system (ANS), which controls visceral functions of the human body, primarily at a subconscious level. The polyvagal theory, which is based on a biological understanding of stress, explains stress as a disturbance of parts of the brain that we cannot gain conscious access to, and centres around the ANS.

The autonomic nervous system consists of two parts: The sympathetic and the parasympathetic system. The sympathetic nervous system mobilizes our energy; for instance, it activates fight/flight behavior when facing stressors; an adaptable function in the short run. The parasympathetic nervous system partly consists of a vagus nerve, which is the interesting part in this regard. This nerve has multiple functions, including influence on diverse aspects like visceral functioning, mood and affects. The vagus nerve consists of two parts: The ventral and the dorsal vagus. The ventral vagus is responsible for our extraversion; it makes us social and directs attention towards the external world. The dorsal part, on the other hand, takes care of basic survival functions like hearbeat, temperature and breathing.

The way we function and go about in our everyday lives are in many respects affected by the balance of these parts of our anatomic nervous system. This includes our psychological well-being, and stress, for instance, throws the system off balance. It is very important to regain control and balance: Initially stress causes the sympathetic nervous system to react with an acute response, which focuses our energy and on the short run enhances our performance when needed. The problems often occur when we experience chronic stress, as chronic stress sidelines both the sympathetic nervous system and the ventral vagus, the latter of the two being the dominant factor when we feel relaxed and secure. Instead, the dorsal vagus becomes dominant, and although stressors and trauma have different effects depending on the person and situation, some common problematic effects of this unbalance may kick in. This can, for instance, be explained using the Window of Tolerance model.

Window of tolerance

In continuation of the polyvagal theory, the Window of Tolerance is a model focusing on the effect of stress and trauma. The window referred to in the model is a range of optimal arousal state, where emotions are tolerable and experiences can be integrated. The Window of Tolerance thus points to the zone of arousal in which we are able to function most effectively, meeting demands of everyday life optimally. This includes making decisions in a calm state, thinking rationally and being ready to receive and process information. The window lies between two extremes, which are connected to the previous explained unbalance of the ANS: In one end, we have sympathetic hyperarousal and at the other end, we have parasympathetic hypoarousal. We risk ending up in one of these states when facing stressors, like different traumas, as these incite both emotional and autonomic dysfunction and unbalance, making it difficult to achieve the optimal state within the Window of Tolerance. Sometimes, living under extreme stress or experiencing prolonged exposure to for instance childhood trauma can even cause the system not only to react when facing a threat, but also in the anticipation of one, causing the individual the experience difficulties regulation affects. Each person's Window of Tolerance is different, and people often move between different states of arousal, but often operating outside the Window of Tolerance can cause metal health issues like anxiety, as it makes a person feel like the world is unsafe, perceiving danger more readily, thus reacting with either fight/flight or freeze responses more quickly. Traumatic events thus often triggers a more narrow or unflexible Window of Tolerance (https://www.goodtherapy.org/blog/psychpedia/window-of-tolerance)

The way to end up in one of the two extreme states is thus connected to the unbalance of the ANS: When the sympathetic nervous system dominates too much or for too long, it causes the hyperarousal-state. When this happens, we tend to become emotionally flooded and react with a fight/flight response. Furthermore, we are at risk of becoming reactive, impulsive, fearful and angry and experiencing things like intrusive affects, nightmares and high-risk behavior. This is important to deal with, as it can trigger negative consequences like self-harm and alcohol or drug abuse. On the other hand, it is not ideal for the parasympathetic system to take over entirely either, thus entering a state of hypoarousal, as this causes a freeze reaction. This incites effects like flat affects and feelings of numbness and emptiness. Hence, we become unable to think, our defensive responses are disabled, and we feel helpless and hopeless with no enthusiasm for life, which can also lead to self-harm and compulsive behavior. At this point, the dorsal vagal nerve has taken over, causing both psychological and physiological numbing characterizing disorders like depression and anxiety (Corrigan, Fisher, & Nutt, 2011).

According to the Window of Tolerance model, the secret of the treatment approach for these types of dysfunctions lies in regulation of the autonomic nervous system; regulation autonomic arousal within a Window of Tolerance: Here, affects and cognitions are tolerable, making patients able to think and feel (ibid.).

One of the ways to (re)gain control of the nervous system seems to be through breathing techniques. When researching these, an abundance of more or less specific techniques shows up; a lot of which are commonly known, but not thoroughly researched. Some of the techniques are interwoven, and the goal of this presentation is to create an overview trying to piece it down, focusing on some of the overall aspects of the techniques, as well as diving into a few commonly used specific methods.

Slow breathing

A central element common to a lot of breathing techniques and methods is the focus on slowing down the breathing rate, as this calms down the system, benefitting both physiological and psychological health. The average person takes a breath 12-16 times per minute, which seems to be a bit too often (Mason, et al., 2013, p. 1; Russo, Santarelli, & O'Rourke, 2017, p. 302). Slow breathing can be defined in several ways but might be defined as any rate from 4-10 breaths per minute (Mason, et al., 2013, p. 300). However, even within this interval, the exacts breathing rate does not seem to be inconsequential: Many studies suggest that the optimal breathing rate seems to be at 5-6 breaths per minute, as this seems to be the optimal rate to reduce the activity of the sympathetic nervous system while activating the parasympathetic system and vagal activity. There is no unequvalent answer to the optimal breathing rate, however, and other studies conclude that this beneficial effects already kicks in at 8 breaths per minute (Komori, 2018; Mason, et al., 2013; Russo, Santarelli, & O'Rourke, 2017).

As earlier mentioned, most studies do agree that slow breathing is correlated with better mental and physiological health. One of the reasons why is that the slow breathing at a rate of about 6 breaths per minute affects the activation of the parasympathetic system. The impact on ANS, amongst others, act on the heart (Tsai, Kuo, Lee, & Yang, 2015) making the individual able to regulate the cardiovascular system and exercise and strengthening autonomic control through breathing. Furthermore, slow breathing thus strengthens the ability to handle various affective and environmental events that causes cardiac changes. One of the ways to measure this impact is through the heart rate variability (HRV), which the nervous system has an important role in regulating. HRV is the variation of the time interval between the heart beats and resonates the sympathovagal balance; the balance between the sympathetic and parasympathetic nervous system. Slow breathing shifts the balance to parasympathetiv dominance, and the calming state this incited influences the HRV. Not only the slow pace of the breathing is influential, though; it also has to do with specific frequencies. A slow respiratory frequency of about 0.1Hz – found at a breathing rate of 6 breaths per minute - generates respiratory sinus arrhythmia (RSA). RSA is a synchronization of heart rate oscillation and respiration cycles that increases cardiac-vagal activity and reduction of the activity of the sympathetic nervous system, which is believed to be caused by RSA's involvement of the vagal nerve. The benefits of slow breathing seem to occur in both symmetrical and asymmetrical breathing. Effects of slow breathing is, for instance, distinct in patients with chronic heart failure, where studies show increase in exercise performance. In this particular case, one of the reasons for the benefits of slow breathing is an increased oxygen absorption, which causes a circular effect as it reduces the need of breathing, automatically slowing the breathing down (Mason, et al., 2013, pp. 1-3; Russo, Santarelli, & O'Rourke, 2017, pp. 301-304; Allen & Friedman, 2012, p. 690; Tsai, Kuo, Lee, & Yang, 2015).

The benefits of slow breathing are vast and complex. They include treatment benefits of autonomic dysfunctions associated with heart disease, hypertension, asthma, posttraumatic stress disorder (PTSD) and depression (Allen & Friedman, 2012). They all seem to be related to the maximization of the HRV and preservation of the functions and balance of the autonomic nervous system, as these both seem to be related to decreased mortality during pathological states and increased life expectancy in the general population. On a psychological level, slow breathing also reduces anxiety (Russo, Santarelli, & O'Rourke, 2017, p. 305f) and is in several studies linked to more efficient stress management than ones without a focus on breathing patterns. Stress management is also linked to the vagal tone, referring to the activity of the parasympathetic nervous system, which is also measured through HRV, indicating the resources available to manage stress. Under some conditions, a drop in vagal activity makes the system able to react according to the demands of the surroundings, corresponding to the acute stress response of the sympathetic nervous system. However, in other cases, like chronic stress, it inhibits the performance of for instance cognitive tasks, which requires a higher level of vagal activity, and slow-paced breathing of about 6 breath cycles per minute has proven to increase the vagal tone (Laborde, Allen, Göhring, & Dosseville, 2017, p. 560f).

The technique of slow breathing can be applied to a wide range of target groups due to the low cognitive demands of the task. Children too have proven to experience the benefits; for instance feeling an increased relaxation. However, it is important to be aware that exercising slow breathing suddenly might be uncomfortable for the first few sessions. Thus, to gain the optimal subjective results, it might be necessary to gradually decrease the breathing rate (Lin, Tai, & Fan, 2014). It is important to be aware of this to be able to counter effects of dyspnea – respiratory discomfort – to maintain the correct breathing rate, especially in patients suffering from emotional disorders like anxiety, as they experience higher rates of dyspnea. Efforts to counter dyspnea can, for instance, be induction of positive emotions during the slow breathing process (Allen & Friedman, 2012)

Deep breathing

Somewhat related to slow breathing, another common breathing technique is deep breathing. Deep breathing is a breathing method that involves engaging and expanding the diaphragm while the abdomen due to inhalation is raised; hence directing air to the abdomen. This allows more air to enter the lunges, reducing wastage of air as dead space decreases as more air mixes with residual air in the lunges. Besides physiological benefits like improved blood flow, decreased pain perception and increased HRV, deep breathing is, like slow breathing, a widespread method of relaxation to reduce tension and improve mood, for instance practiced in yoga (Szabo & Kocsis, 2017, p. 565; Perciavalle, et al., 2017; Cheng, Han, & Lee, 2018). This is the case as deep breathing is another simple relaxation technique, which, for instance, also has proven to be efficient in decreasing arousal and reducing activity of the sympathetic nervous system (Chung, et al., 2010). Using the diaphragm in breathing increases relaxation and gas exchange maintain health of tissues and muscles. In one study, the effects of deep breathing are measured through both self-reported mood and stress as well as through psychological measures of heart rate and salivary cortisol, since an increased heart rate often is associated with stress, while cortisol is a stress hormone. The study involved a group of 38 healthy students, who performed deep breathing in 10 sessions once per week for 90 minutes, and deep breathing caused significant differences from the control group performing normal breathing in both reported mood and levels of stress. Heart rates and levels of cortisol dropped. The effects were present in both beginning and at the end of the training, and similar results have been found in other studies. Hence, there seems to be a great potential in the deep breathing technique regarding stress management (Perciavalle, et al., 2017).

The technique is, moreover, easy to apply and cost-effective; a tool easily accessible to both children and adults that, once learned, can become a self-regulatory tool. The effectiveness of deep breathing is connected to slow breathing, as the deep breaths also automatically means slowing down breathing. Deep breathing is thus related to both affective and autonomic arousal states; it relaxes the system and incites pleasant affects, promoting the ability to manage anxiety related symptoms. A study focused on the role of deep breathing on state anxiety and test performance in 122 students shows that deep breathing has the potential to lower anxiety and enhance performance (Khng, 2017). In continuation hereof, abdominal deep breathing can be seen as a form of mindfulness tool that helps students develop skills as well as managing emotions, which is related to mindfulness' purpose of paying non-judgmental attention to the present moment. Attentiveness and deep breathing combined can improve the emotional state as well as facilitating the management of feelings of stress and anxiety and regulation of emotions. Deep breathing as a mindfulness tool can potentially increase calmness, relaxation and self-acceptance. Mindfulness is based on the fact that the brain is able to change its structure and function, wherefore the breathing exercise takes time to show results and relies on the willing participation of the individual (King, Henderson, & Sandhu, 2018). This might be connected to the impact deep breathing might have on the neurophysiological level, causing cognitive implications: Deep breathing seems to affect brain functioning, modulating aspects like retention of newly learned motor skill, attention, emotion and mental health. Early studies for instance support the above-mentioned theory that low low-frequency breathing of 0,1 Hz – happening at 6 breaths per minute - can reduce stress. Deep breathing is also linked to mindfulness as the technique facilitates the focus of attention, and the shift from domination of the sympathetic to parasympathetic nervous system; reducing anxiety. For benefits to kick in, though, deep breathing must take place over a period of time; thus needing to practice and taking precautionary steps to avoid discomfort (Cheng, Han, & Lee, 2018).

Another study of patients with coronary heart disease and depression shows that depression scores decreased as a result of home-based deep breathing programme performed for two weeks (Chung, et al., 2010). This is important, as factors like emotions affect heart disease, and comorbidity if often found between cardiovascular and psychiatric disease; some of the latter being anxiety, depression, social isolation and stress. Anxiety, for instance, is also correlated with higher blood pressure and heart rate. Deep breathing can contribute to reducing risk factors as it reduces systolic blood pressure and anxiety (D'silva, Vinay, & Muninarayanappa, 2014).

Inhalation/exhalation (I:E) ratio

It is a common saying to take a deep breath, when stressed out, panicked etc. But actually, this might not be the accurate description of what the body needs to calm down. According to some research, the more important thing is to focus on exhalation, which might be affected by the fact that heart rate increases during inhalation, while it decreases during exhalation (Allen & Friedman, 2012). Some studies focuses on so-called *prolonged expiration*, which means a longer exhalation than inhalation. The specific ratio varies from study to study: Some studies uses 2:3 ratios (4 seconds inhalation, 6 seconds exhalation), some a 1:2 ratio and others different ratios.

Prolonged expiration amongst others helps avoid hyperventilation and reduce both physiological and psychological arousal. This might also be the case in general when individuals implement techniques to control their respiration, but control of respiratory cycles, that is I:E-ratio, can contribute to greater and more lasting reduction of arousal. For arousal reduction specifically, a slower respiration combined with prolonged exhalation seems particularly effective in both anticipating and confronting a threat (Laborde, Allen, Göhring, & Dosseville, 2017; Cappo & Holmes, 1984). Prolonged exhalation for instance indices a higher vagal tone, which as above mentioned enhances stress management skills (Laborde, Allen, Göhring, & Dosseville, 2017, p. 561). This might be caused by the shift towards domination of the parasympathetic nervous system, measured high and low frequency of HRV as this represents the parasympathetic nervous activity and sympathovagal balance to the heart. Prolonged expiration shows significantly activation of the parasympathetic nervous system in a study using a 2:3 inhalation/exhalation ratio (Komori, 2018). A low compared to high I:E ratio also incites higher pleasantness doing the breathing techniques as well as a feeling of more control. This can be accompanied by more relaxation and energy, less stress and higher mindfulness. One possible explanation is the fact that inspiratory muscles relax during exhalation (Van Diest, et al., 2014).

But the positive effects of prolonged expiration might not be entirely restricted hereto: Some studies suggest that similar benefits are found with equal I:E-ratios, meaning equal length inspiration and expiration. One study even compares I:E ratio of 5:5 and 4:6, and finds that the equal I:E ratio seems to be more influential as it causes a greater increase in cardiac vagal activity compared to the prolonged breathing technique, while PNS is also activated, causing a relaxed state of the system (Lin, Tai, & Fan, 2014)

Breath retention

Breath retention is all about creating resistance during breathing. It is for instance part of a yogic tradition called Ujjayi, which also reduces airflow. During expiration, the resistance breathing causes pressure on the thorax as the glottis muscles slightly contracts, and this has the potential of stimulating vagal activity and, like slow breathing, enhancing oxygen absorption. Breath retention might also be an effective tool in gaining more control over your breath, making it easier to achieve slower breathing rates, although the effort put into exhaling might trigger activity in the sympathetic nervous system; thus working against the relaxing benefits of the other elements of for instance slow breathing (Mason, et al., 2013, p. 1f). Long breath holds causes a reversion of carbon dioxide gas exchange to reabsorb oxygen and has the potential to reset abnormal breathing rythms, like hyperventilation (Afle & Grover, 2014, p. 118f). However, prolonged breath retention should be done with caution and practice to avoid side effects like high blood pressure; before practicing breath retention, other techniques like slow, deep breathing and elongated inspiration and expiration should be mastered (Nivethitha, Mooventhan, & Manjunath, 2017).

Buteyko method

In the 1950s and 1960s, Konstantin Pavlovich Buteyko began treating patients sufferings from respiratory and circulatory diseases using the Buteyko Method based on breath control and breathing retraining. The method might be efficient due to the use of breath hold, which minimizes hyperventilation, thus lowering the carbon dioxide in the body. Furthermore, the method teaches the individual to reduce the volume of breathing, thus slowing breathing rates down due to increasing use of abdominal muscles and relaxation of accessory muscles of breathing making it more effortless to breath using the diaphragm. Since then, studies have been made into its effectiveness towards for instance asthma (Russo, Santarelli, & O'Rourke, 2017, p. 300; Afle & Grover, 2014).

Since then, it has also been applied to other conditions like anxiety and sleep apnea. The Buteyko Breathing Method claims that its effectiveness is due to the effect is has on carbon dioxide levels, as many conditions are believed to be aggravated by low carbon dioxide levels and hypocapnia. The carbon dioxide theory is a big part of the Buteyko Method, where the primary aim is to raise carbon dioxide levels. Especially hyperventilation is thought to be a main culprit affecting both physiological and psychological states. Evidence confirms parts of this theory, but a lot is yet to be tested regarding the vital importance of carbon dioxide levels in relation to the Buteyko Method. Most research focuses on its effectiveness on asthma, where there is a great deal of evidence into the effectiveness of the theory, and these have shown the potential of reduction of medication, although no objective changes are seen in the lung function. Most results also point towards the greatest effectiveness being towards quality of life. The CO_2-theory has proved to be too simplistic and although a lot of stories are found about the life chancing effect this method has had on both physiological and psychological health, more research into the scientific effectiveness of this method is needed. Recent research does point to the fact that the Buteyko Method has significant effects on end tidal volume, breathing rate and predicted forced expiratory volume.

What seems to be efficient is the breathings pauses included in the Buteyko method, as these seem to increase CO_2-levels. This makes it easier to comfortably hold one's breath.

Along with the idea of breathing less rather than more, breath retention is considered as important as breathing itself. The main breathing technique is called reduced volume breathing: This involves sitting with an erect position and relaxing the respiratory muscles until you feel a slight breathlessness, which is maintained by the combination of an erect position, relaxation of breathing muscles and a slight tension of the abdomen. Breathing takes place through the nose, and breath retention happens in two ways: Short pauses called Control Pauses and longer pauses called Maximum Pauses. Control pauses entails holding your breath after a gentle exhalation until you feel the urge to inhale, while Maximum Pauses goes even further, holding your breath for as long as you can. A session usually takes about 40 minutes, but when it is mastered, the point is to apply the technique into one's everyday life; for instance in controlling symptoms and resetting some breathing patterns.

Breath holding is a technique shared by for instance Buteyko and yogic breathing. Breathing with the Buteyko method, however, entails using low lung volumes, which is the opposite taught in many yoga practices, which will be the focal point of the next section. The low volume breathing has a relaxing effect on respiratory muscles as it reduces the efforts of breathing and enhances the use of the diaphragm. This might reduce the volume of air trapped in the lungs, making people less breathless. If a person experiences hyperinflated lungs, deep breathing might have the opposite of the wanted effect, which is why reduction of hyperinflation can make breathing more efficient (Rosalba, 2008; von Bonin, et al., 2018)

Yogic breathing (pranayama)

A lot of breathing techniques has root it the practice of yoga (Van Diest, et al., 2014), where breathing is considered a bridge between body and mind. There are different types of yogic breathing techniques, but one of the widespread practices is the regulated form of breathing characteristic of yoga called *pranayama*: A form of control and elongation of breath (Nivethitha, Mooventhan, & Manjunath, 2017) that is not abdominal, where slow breathing at about 6 breaths per minute is introduced (Chaddha, 2015). Pranayama is an old practice introduced in the West in the late 1800s, which performs controlled breathing; often combined with meditation or yoga. There are different forms of pranayama with different focuses like nostril breathing, abdominal breathing and vocalized breathing and these are performed with various ratios and depths (Russo, Santarelli, & O'Rourke, 2017, p. 299). Yogic breathing in the form of pranayama has over the years proven to have positive effects on the human physiology. Pranayama exists in different forms and can consist of aspects like inhalation, called Pooraka, exhalation, called Rechaka, internal breath retention, called Antar kumbhaka and external breath retention, called Bahir kumbhaka. These can be used individually or combined to gain various physiological response, depending on the type and duration of the practice (Nivethitha, Mooventhan, & Manjunath, 2017; Kuppusamy, Kamaldeen, Pitani, & Shanmugam, 2018). Like the other breathing methods, the effect of yogic breathing relies om the downregulation of the sympathetic nervous system, promoting relaxation and stress relief. Studies show that pranayama can have a positive effect on hypertension, breathing frequency and stress, but also on HRV and the sympathovagal balance, which, as earlier mentioned, is crucial to the ability to function in our everyday lives. Due to the bi-directional connection with physiological diseases like cardiovascular disease, pranayama has also proven effective in the prevention of these diseases; maybe because of the effects on stress and anxiety. Physically, pranayama incites lower blood pressure due to the effect on the nervous system. The most influential factors for these changes seems to be the slow breathing as it induces parasympathetic dominance, but also due to various other positive effects on the neural system, brain functioning and general physiology (Chaddha, 2015).

For instance, pranayama can reduce oxygen consumption, which might be due to the combination with the psychical activity of yoga. Oxygen consumption is important for everyday life, as it can be used as part of the determination of energy requirements necessary for living a healthy lifestyle and exercise, as well as being important for ill people. The consumption of oxygen tends to increase with the level of stress, which is why stress relies (Tyagi & Cohen, 2013). Continuous practice has the potential of reducing the dead space ventilation, like earlier mentioned, and to ease the effort of breathing; the entire lung is taken into use instead of breathing shallowly. Besides inciting parasympathetic dominance in the nervous system, it has a positive impact on the cardiovascular system and the respiratory functions in general, which is interwoven with the stress-relieving impact (Kuppusamy, Kamaldeen, Pitani, & Shanmugam, 2018).

2:3

This breathing technique is related to many of the previous mentioned techniques but is found to be the state of the art; the optimal way of breathing to gain the abovementioned benefits. The use of the 2:3 breathing method means taking advantage of prolonged expiration, which is proposed to happen under strictly control to ensure the technique is followed and full advantage gained: A virtual programme does the counting to ensure correct usage, avoiding too much focus on the technique and thus enhancing the relaxing effect. This way, the breathing becomes fully rhythmical. Most studies agree that the optimal breathing rate per minute is 6, which means that the optimal 2:3 breathing technique would be implementing inhalation of 4 seconds and exhalation of 6 seconds (Chaddha, 2015)

http://www.nicabm.com/trauma-how-to-help-your-clients-understand-their-window-of-tolerance/

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