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REVIEW PAPER

Reviewing the Relationship between Physiology of Breathing and Physical Activity in Anxiety Disorders

Alessandro Nota[1], Goran Kuvacic[2], Maha Sellami[3] and Andrea De Giorgio[4]

[1]Vita-Salute San Raffaele University and IRCCS San Raffele Scientific Institute, Milan, Italy, [2]University of Split, Faculty of Kinesiology, Split, Croatia, [3]Qatar University, College of Education, Physical Education department, Doha, Qatar, [4]eCampus University, Department of Psychology, Novedrate, Italy

Abstract

The possible influence of the quality of breathing on physical activity remains the subject of numerous scientific studies in different fields, including not only the most basic physiological and biological concepts but also the fields of psychiatry, psychology, and neuroscience. The literature about the relationship between breathing and psychophysiological factors is continuously growing, and several studies have investigated the influence of breathing techniques on human beings. This review aims to give a literature overview of the respiratory function impact on psychopathology, taking into account anxiety disorders, physical activity, and the relationship between them. Literature investigating different topics involving the influence of breathing on anxiety disorders, the influence of breathing on physical activity and related anxiety disorders showed an association between them even if this relationship is not well clarified. Regular physical activity could become even a primary or preferential treatment. Relaxation techniques, as well as motor visualization, mindfulness, and even oral appliances, could help people improve their general condition with the improvement of the control of their psychophysical performance. Further literature with different physical activities and experiences regarding psychodynamic treatments could assume a new scenario.

Keywords: *mindfulness, relaxation techniques, panic disorder, psychopathology*

Introduction

Accounts of physically active people (e.g., fitness exercise) shed light on the phenomenon of anxiety problems widespread in the physical activity field and often experienced by younger athletes (Ford, Ildefonso, Jones, & Arvinen-Barrow, 2017) and by high-level athletes. Stiene (1992) reported a case of a young basketball player with dyspnea and chest pain who had lost consciousness for twenty seconds due to having a syncope during a match. After having excluded all the possible organic causes by applying adequate cardiologic, neurologic, and metabolic testing, the episode was considered a panic attack with psychogenic aetiology.

As extensively elaborated by the scientific literature, chest pain is often associated with the typical symptom of air hunger, leading subjects to think that they are close to death (Durazzo, Gargiulo, & Pellicano, 2018). Beyond the empirical evidence, the possible influence of the quality of breathing on sports performance remains the object of numerous scientific studies in different fields, including not only the most basic physiological and biological concepts but also the fields of psychiatry, physiology, and neuroscience (Bordoni, Purgol, Bizzarri, Modica, & Morabito, 2018). In particular, recent studies in the field of neurobiology have shown a close relationship between breathing and the nervous system involved in stress responses (Yackle et al., 2017).

Moreover, a strong relationship between breath rate, mood state, and autonomic nervous system state has been shown (Zaccaro et al., 2018). Fast breathing stimulates brain

Correspondence:

G. Kuvacic
University of Split, Faculty of Kinesiology, Teslina 6, 21000 Split, Croatia
E-mail gorkuv@kifst.hr

activity at a higher rate, triggering it to activate the sympathetic nervous system, accelerating the release of stress hormones, increasing heartbeat, blood pressure, muscle tension, sweat production, anxiety, and even panic disorder (see, e.g., Dratcu, 2000). The interest in the scientific literature about the relationship between breathing and the brain is continuously growing; several studies have investigated the influence of breathing techniques, especially yoga, on sports performance. While the growing importance of breathing techniques and exercise is obvious in the training of swimmers and apnoea athletes (Lomax, Tasker, & Bostanci, 2015), where the optimization of pulmonary function is directly related to the performance, the interest in the application of these techniques in other sports fields is also increasing (Zhang et al., 2015). The focus of researchers is on studying the relationship between respiratory function and anxiety, hypothesizing a relationship between breathing and the brain beyond the direct physiological connections (Carter & Carter, 2016; Zaccaro et al., 2018). This literature review aims to show the scientific framework of the impact of respiratory function on psychopathology concerning anxiety and panic disorders related to sports performance.

Intensity differentiates a panic attack from an anxiety attack (Figure 1). According to the medical definition, "Panic attacks are acute anxiety attacks"; they are episodes of anxiety that happen suddenly and end just as quickly, usually lasting between 5 and 30 minutes (DSM-5; American Psychiatric Association, 2013). A panic attack is also a relatively common phenomenon; it is estimated that about one in twenty people experiences one during their lifetime (Kessler et al., 2006); females predominate.

According to DSM-5 (American Psychiatric Association, 2013), the most common physical symptoms regarding panic attack are feelings of choking and breathing blockage, feelings of tightness or even chest pain, palpitations, sweating, tremors, abdominal pain, and nausea, and vomiting. Equally violent psychological symptoms accompany these different somatic symptoms. If the anxiety crisis is a crisis of malaise, a heart that is pounding, or difficulty in breathing, the panic attack is fierce. More physical symptoms are present: palpitations, an impression of suffocating (even being strangled), pain or chest discomfort, feeling dizzy, nausea, hot flashes, decreolization (feeling of unreality or strangeness of the outside world), depersonalization (feeling alien to one's own body).

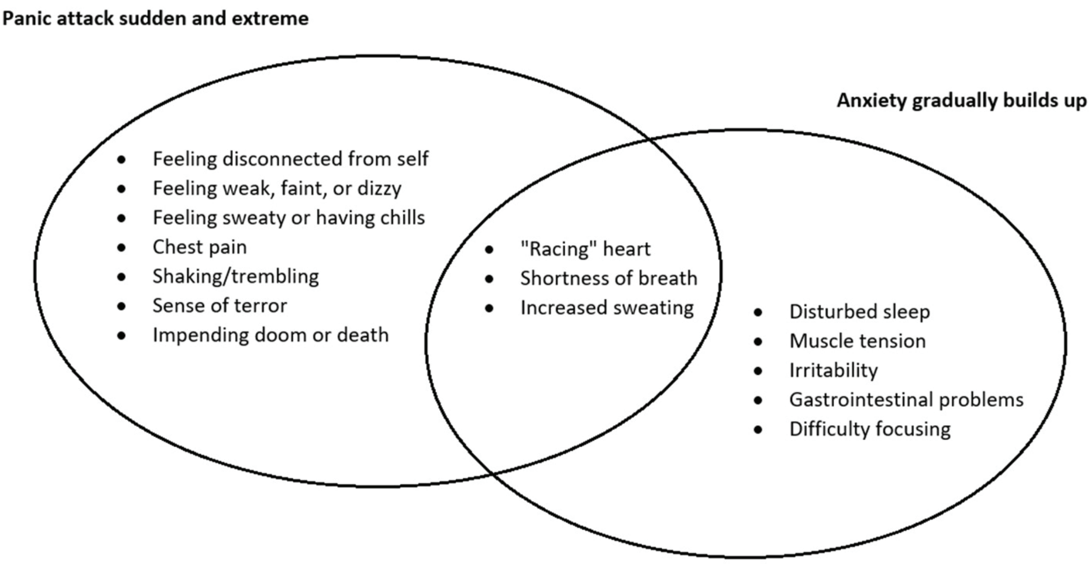

FIGURE 1. Panic attack vs Anxiety attack symptoms

Breathing and Panic Disorder

Panic disorder: the respiratory subtype

According to the last edition of the Diagnostic Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), panic disorder is considered as a single diagnostic category included in a broader group of anxiety disorders. Thirteen physical and cognitive symptoms characterize anxiety disorders: palpitations, tachycardia, increased perspiration, tremors, chest pain, nausea, abdominal disturbs, vertigo, fainting, chills, hot flushes, paraesthesia, derealization, depersonalization, fear of losing control or "going crazy", and fear of death, dyspnea, and suffocation. These clinical symptoms define a particular disorder subtype known as the respiratory subtype (Freire et al., 2008). Consequently, patients with respiratory symptoms are classified in the respiratory subtype group, while patients with the predominance of other physical or cognitive symptoms are in the nonrespiratory subtype group. Freire, Perna and Nardi (2010) state that further studies are necessary to determine a sufficient possibility of identifying the respiratory subtype of panic disorder. In particular, these authors assume that other factors that should be considered are cultural differences, smoking tobacco, alcohol assumption, or the response to specific therapeutic treatments. Furthermore, it is suggested that this research not based merely on the symptomatologic profile but also that respiratory tests, neuroimaging, and genetic tests be performed. For example, respiratory testing is very important in obese people, given that a relationship between body mass index and lung function has been determined, which also varies with age, race, and geographical region (Wang, Sun, Hsia, Lin, & Li, 2017).

Moreover, the literature describes that obese binge eaters have significantly higher frequencies of typical and atypical panic symptoms and agoraphobia than controls do (Zoccali et al., 2004). It can be inferred that there is a mutual influence between difficulty breathing and obesity, which, in turn, makes these people more exposed to psychological problems. Finally, those people in the respiratory subtype should pay greater attention to their physical sensation, developing significant anticipatory anxiety contributing to lowering the threshold of panic activation in relationship with external and internal stimuli. For these reasons, subjects in the respiratory subtype present quite catastrophic perceptions regarding their symptoms compared to the nonrespiratory subtype (Song, Kim, Heo, & Yu, 2014).

The close relationship between panic disorder and respiratory function, which is a part of the nonrespiratory subtype, encouraged researchers to specifically investigate the nature of this relationship, considering the hypothesis of a causal relationship. It was especially hypothesized that panic disorder could be related to an anomaly of physiological mechanisms of the respiratory function. As discovered in the late 1990s (Perna, Bertani, Politi, Colombo, & Bellodi, 1997; Perna, Giampaolo, Caldirola, & Bellodi, 2004), respiratory control mechanisms play a crucial role in the origin of abnormal anxiety and panic disorder. A team from the Laboratory of Panic and Respiration of the Psychiatric Institute of the University of Rio de Janeiro carried out a series of tests in order to evaluate the presence of physiological anomalies of breathing in subjects affected by panic disorder; the experimentation included the evaluation of hyperventilation, apnoea, $CO2$ inhalation and caffeine consumption, demonstrating that there is an increase of anxiety, and panic attack risk was noticed in subjects with panic disorder during these tests (Nardi et al., 2007; Nardi et al., 2006). Specifically, the hyperventilation syndrome, which can be observed during panic attacks, has been characterized as having two forms: chronic and acute (Gorman et al., 1994). Gorman, Kent, Sullivan and Coplan (2000) discussed a model by which it is possible to highlight that disturbed breathing could provoke bursts of hyperventilation and respiratory alkalosis, which can result in dizziness, palpitations, and tremors, which, in turn, worsen fear and anxiety. However, the existence of an evolved "false suffocation alarm" has also been proposed, which can trigger panic attacks caused by the brain that incorrectly signals a lack of useful air; so the brain activates maladaptive autonomic responses to suffocation, demonstrating that $CO2$ sensitivity might play a crucial role in breathing disorders (Preter & Klein, 2008). Of the two proposals, hyperventilation has particularly been considered closely related to panic attacks, leading the researchers to describe the hyperventilation syndrome (R. Zeng, Chen, & M. Zhang, 2018) as a real triggering cause of this phenomenon. According to this hypothesis, subjects affected by panic disorder could be considered to be chronically affected by hyperventilation in a hypomanic alkalosis state (a condition with blood pH higher than the normal value of 7.4). This hypothesis is based on the evidence of at least three experimental data groups: a) panic attacks and hyperventilation syndrome have a common symptomatology (dyspnea, palpitations, tremors, paraesthesia, fainting); b) hyperventilation syndrome is present in about 40% of subjects with panic disorder (Nardi et al., 2001); c) the hyperventilation test (during which the subject is asked to hyperventilate for 4 minutes (30 breaths/minute)) causes symptoms the same as what was reported happening during panic attacks by subjects with panic disorder (Nardi et al., 2004). However, according to the authors (Nardi et al., 2001), such empirical evidence is insufficient to establish an etiological relationship between breathing and spontaneous panic attacks.

Griez and Perna (2003) reported that panic disorder is not necessarily related to any objective respiratory pathology, and the normal physiology of respiration is maintained in subjects suffering from panic disorder. The tendency of those subjects to hyperventilate or to panic when encountering respiratory stimuli, such as inhaling carbon dioxide, seems mostly to activate a network of fear reactions. Nardi and his colleagues (2001) hypothesized the existence of subclinical anomalies in respiration and other functions of homeostasis in the body. Fear control is quite complex, and the brain areas involved are represented by the amygdala and its projections in the brain stem, hippocampus, and medial prefrontal cortex. The amygdala is abnormally sensitive in subjects suffering from an anxiety disorder in which the prefrontal cortex, usually able to modulate the amygdala's activity, fails his control; this is the so-called "insufficient top-down control" (Dong et al., 2019). This theory could explain why these subjects react positively to both medical and psychological therapies.

Furthermore, it has been demonstrated that mindfulness approaches can improve the prefrontal cortex efficiency and its control on the amygdala activity (Cheng et al., 2010). Therefore, the anomalies in different neurochemical systems could be the expression of complex relationships that intervene between the brain circuits, so panic disorder should be entirely interpreted due to multiple complex interactions between different brain circuits (Nardi et al., 2009).

Finally, studies conducted since the end of the 1990s also tended to exclude a causal relationship between breathing anomalies and panic disorder (Perna et al., 2004). A study based on the analysis of the entropy index in subjects with panic disorder compared with healthy subjects showed that these subjects are characterized by an entropy index higher in the basic respiratory model (Caldirola et al., 2004). This finding suggests a higher level of irregularity and complexity in their respiratory function; even if this could be lead to panic attacks, it does not imply a causal relationship between these two phenomena.

From physiology to neurobiology

Current research seems to pay more attention to the complexity of the panic disorder phenomenon, an approach that tends to exclude a one-way relationship with the physiology of breathing. The field of neurobiology seems to be the most promising one as far as this issue is concerned. A study by Yackle et al. (2017) focused on the analysis of neural mechanisms and centres at the basis of the relationship between breathing and the brain. In particular, they found a small, molecularly defined neuronal subpopulation in a breathing rhythm generator that directly projects to a brain centre, which plays a key role in generalized alertness, attention, and stress. Among the 3000 neurons of the pre-Bötzinger complex, responsible for initiating respiratory movements, a group of about 175 neurons seem to send projections directly to the locus coeruleus, a part of the brain that has a key role in the general supervision, in focusing attention, and in stress responses (Yackle et al., 2017). The pre-Bötzinger complex should act as a "respiratory pacemaker" involved in all kinds of breathing associated with different emotions: regular, relaxed, excited, panting, sobbing, and sighing. Thus, it was hypothesized that different neuronal subtypes of the respiratory centre were related to different kinds of breathing. After more than 60 neuronal subtypes were identified in the brain stem of the respiratory centre, their role in breathing was studied in rats by selectively eliminating each subtype. It was found that while there were no changes in breathing after eliminating the identified neurons, the rats stayed unusually calm even exposed to stimuli that generally induce a stress response (Yackle et al., 2017).

These findings could be both proofs of a neurological origin of the relationship between respiration and panic disorder and the basis for developing new clinical therapies for panic attacks (Wemmie, 2011). In particular, isolated neurons could be identified with specific molecular markers, and it would be possible to develop new drugs that can selectively act on specific neuronal subtypes (Hockley et al., 2020). Breathing is a complex phenomenon characterized by both automatic and voluntary behaviour; the voluntary behaviour centres that control it coincide with superior neural functions. Both automatic and voluntary behaviour can be influenced by mindfulness and meditative practice techniques, which could positively influence the treatment of psychiatric disorders (Hofmann & Gómez, 2017; Zeng et al., 2018).

Breathing control, therefore, seems to play a crucial role of primary importance effectively, not only at the basic physiological level (it is a known fact that oxygen consumption is increased in stress conditions) but also in the context of superior cognitive activities such as focused attention or the mindful stress control. Consequently, mindful control of breathing results as a fundamental instrument to optimize respiratory potential and modulate the emotions that affect daily life (De Giorgio, 2016) and breathing itself (Allen & Friedman, 2012; Arch & Craske, 2006). Meditation techniques based on the control of breathing, used for centuries for promoting concentration and relaxation before an important and demanding physical and mental performance, seem to be effective on the neuronal mechanisms that regulate the relationship between breathing and the brain (Yackle et al., 2017; Young et al., 2018).

Breathing and Physical Activity

Physical activity and psychopathology

Respiratory dysfunctions related to panic attack symptoms are among the principal causes of avoiding physical exercise (Muotri & Bernik, 2014). It should be underlined that panic attack is not a DSM-5 disorder; thus, it cannot be considered a real psychiatric disorder. However, it could be defined as a disorder in case of repeated panic attacks without a clear trigger cause, thus keeping the subject in a continuous state of concern. According to the DSM-5, avoiding physical exercise represents a maladaptive change of behaviour, which can be compared to a whole reorganization of daily life, including a limitation of daily activities, from leaving the house to avoiding agoraphobic situations and, finally, ensuring aid in case of a panic attack. Regardless, the scientific literature seems to be addressed to demonstrating that physical activities could have a positive effect on reducing symptoms in subjects suffering from panic disorder (Aylett, Small, & Bower, 2018). In their review, Aylett et al. (2018) emphasized that people with a diagnosis of anxiety disorder according to the DSM IV criteria, or high anxiety levels/anxiety sensitivity levels on a validated anxiety rating scale, receive greater benefit from high-intensity than low-intensity exercise, with a significant effect size of -0.38 (95% CI -0.68 to -0.08).

Moreover, the follow-up scores in high-intensity exercise regarding the investigated literature indicate that improvement in anxiety levels is permanent for several months after training, with a non-significant effect size of -0.33 (-0.74, 0.08). The study of anxiety and its relationship with other psychological variables, as well as its consequences, has a long history in the scientific literature in sports medicine. Nowadays, every sport psychology and psychiatry manual includes a chapter about anxiety disorders (Currie & Owen, 2016). In recent decades, several theoretical instruments have been developed to measure sport-specific anxiety traits. For example, at the end of the 1970s, the "Sport Competition Anxiety Test" was developed (Martens, 1977): a one-dimensional measure unable to differentiate between somatic and cognitive components of anxiety. In the 1990s, this model was integrated by another research study in order to include two dimensions of the disorder and, in particular, to represent the anxiety disorder in all its somatic, cognitive, and affective complexity. For this purpose, another multidimensional model was developed, called the "Sport Anxiety Scale" (Smith, Smoll, & Schutz, 1990). Smith himself implemented it in his updated version "Sport Anxiety Scale-2" in the 2000s. The latter has higher factorial validity and considers numerous psychological measures with particular attention to childhood and adolescence periods (Smith, Smoll, Cumming, & Grossbard, 2006).

However, these models are applicable only within the world of sport, to subjects who regularly practice sports activities and not subjects who intend to do intense physical exercise as a potential cure for anxiety disorders. Therefore, a specific approach should instead be applied to professional athletes. According to a study by Ströhle et al. (2009), as the anxiolytic effect of physical exercise is well known both in healthy subjects and subjects affected by anxiety or psychiatric disorders, it should be underlined that the agonistic physical activity could have a negative effect on the latter, causing an increase of disorders instead of a decline. In addition, in this case, some differentiations should be done regarding both the physical activity type and the type of disorder from which the subject is suffering.

Szabadi (1988) assessed the psychological effects of different types of physical exercise in subjects with different mental disorders, such as anxiety, depression, and mood disorders. In particular, Szabadi distinguished aerobic or cardio-respiratory exercises, such as long-distance running, anaerobic exercises (based on muscular strength), such as weightlifting, exercises for relaxation, and exercises for coordination and flexibility, such as yoga. The author considered different variables, such as the diagnosis of the subject assessed and the selection of treated groups and the training regime, and found that regular aerobic exercise can have positive psychological effects in subjects affected by anxiety disorders and depression.

According to a study published by Heidary et al. (2011), subjects mainly doing aerobic exercises have a lower stress level and a better ability to control stressful conditions. These findings led to a hypothesis of including physical exercise in primary and secondary preventive plans and therapeutic plans for psychiatric disorders, on the same level as psychotherapy and psychopharmaceuticals (A. Byrne & D.G. Byrne, 1993). The scientific literature seems to demonstrate that moderate physical exercise (20 minutes sessions) for at least 12 weeks positively affects stress control (A. Byrne & D.G. Byrne, 1993). Considering that secondary negative effects of physical activity, applied to subjects under treatment for anxiety, depression and mood disorders, have still not been observed, this activity could be indicated as a primary and preferential treatment (A. Byrne & D.G. Byrne, 1993; Ströhle et al., 2009). However, more recent literature (summary findings presented in Table 1) demonstrates that also anaerobic exercise, in particular yoga and its variations, has a great effect on psychological indexes, including anxiety (Breedvelt et al., 2019; De Giorgio, Padulo, & Kuvačić, 2018; Kuvačić et al., 2018; Telles et al., 2019).

It is important to note that regular and constant physical exercise could also assume traits of addiction in subjects with anxiety and obsessive disorders (Bär & Markser, 2013; Johnson, 1995). Thus, in subjects with dysphoria, physical activity could negatively affect their mental health if the habitual physical exercise programme is interrupted (Paluska & Schwenk, 2000). A typical example is "obligatory runners" or compulsive runners, who practice intense physical activity as an absolute need instead of pleasure (Hoffman & Krouse, 2018; Johnson, 1995).

This condition could be considered similar to a strict alimentary regime; Yates hypothesized that it could be a symptom of the same psychopathological structure as anorexia nervosa (Yates, Leehey, & Shisslak, 1983), based on which the so-called "athletic anorexia" was introduced (Bär & Markser, 2013). In particular, Yates et al. (1983) compared a group of anorexic men with a group of marathon runners and observed some similarities in both personality features and socio-cultural habits. In this respect, studies regarding personality are well developed and concentrated on the obsessive-compulsive traits of athletes with addiction to physical activity and perfectionistic and narcissistic rituals observed in this category of subjects (Stillman, Cohen, Lehman, & Erickson, 2016). Epling and Pierce (1996) and other authors have observed that excessive physical exercise can cause a loss of appetite and decreased food intake, leading to active anorexia and to the phenomenon of "self-starvation", meaning death caused by lack of food.

Interestingly, though physical activity has many positive effects on the nervous system and the brain (De Giorgio et al., 2018; Stillman et al., 2016), in some cases, it could be associated with, or even cause, psychological or psychiatric disorders related to anxiety and panic disorder in the context of high-level agonistic physical activity (Chekroud et al., 2018). Jones (1995), for example, considers the need of deepening the research in this field to investigate the sport-specific psycho-social factors involved in the psychopathological symptoms noticed in these subjects. Reardon (2017) carried out a recent study that gives a clear insight into the relationship between psychiatric disorders and physical activity. In particular, the author explains how physical activity could be the origin of developing a psychiatric disorder or deepening an existing one. This is often the case of eating disorders in athletes, such as gymnasts or bodybuilders, who are under constant pressure to control their weight for competitions. Similarly, in athletes who started their sporting career due to pre-existing psychiatric disorders, so that the developed symptom becomes somehow adaptive to the sporting activity undertaken, an example could be seen in subjects with attention deficit disorder and hyperactivity who started physical activity at an early age in order to dissipate their excessive energy (Reardon, 2017). Finally, a contingent coincidence between sport and mental disorder could be present in subjects with stress-related or genetic mental disorders.

Reardon (2017) observed a small number of studies on anxiety disorder compared to studies on depressive disorders. As far as anxiety disorder is concerned, it is fundamental to distinguish physiological anxiety symptoms related to the contingency of competition from pathological disorders. It is also quite frequently observed that there is an overlapping between these types of symptoms. If anxiety is present before the competition, it can also have a positive effect on the performance, whereas psychopathological anxiety disorder could be disabling for an athlete's life as well as performance, leading to avoidance of physical activity as determined by the respiratory symptoms of panic disorder (Paluska & Schwenk, 2000).

In most cases of anxiety disorders and, in particular, panic disorders in professional athletes, cognitive-behavioural therapy is generally recommended, owing to its absence of influence on sports performance, with side effects generally reported in the pharmacological therapy with benzodiazepine and beta-blockers (D. Baron, Reardon, & S. Baron, 2013). Cognitive-behavioural therapy can also be complemented by antidepressant drugs, such as fluoxetine and selective serotonin re-uptake inhibitors (SSRI; Baron et al., 2013). In some sports, anxiety can also be accompanied by panic. Among the most studied examples in this regard, sport diving should be mentioned, for which anxiety and panic disorder are directly and explicitly related to respiratory function. In fact, many of the numerous accidents occurring at an amateur or competitive level in this sport are related to panic reactions (Morgan, Raglin, & O'Connor, 2004).

Studies carried out by Morgan et al. (2004) in the Sports Psychology Laboratory of Madison-Wisconsin University showed the importance of a clear awareness of one's respiratory function related to one's traits and psychological state in the practice of sport diving activities. In extreme cases, such as for the selection of special armed forces, a screening of any kind of psychiatric and psychological disorders is performed before any evaluation of athletic, endurance, and training capacities of subjects. During diving, self-control of the psychophysical reactions to stressful or dangerous situations is more fundamental than in any other sport. For this reason, the teaching of correct breathing was suggested to be included in educative programmers, similar to sexual and nutrition education (Starosta, 2013). Starosta observed that learning "rational breathing" techniques consisting of a conscious connection between breathing and movement rhythm could improve sports performance and the general state of health of the subject. Regarding specific sport fields, Starosta outlines a detailed summary of the respiratory modalities suggested for each sport exercise and discipline aiming to diffuse an "art of breathing" as proposed by Asian cultures.

Table 1. Summary findings of physical activity effects in psychopathology

Study	Type of exercise	Population	Results
Szabadi (1988)	Regular aerobic or cardio-respiratory exercises	Participants affected by anxiety disorder and depression	+ Psychological effects
Bär and Markser (2013);	Regular and constant physical exercise	Participants with eating disorders, exercise addiction, chronic traumatic encephalopathy, and mood disorders in overtraining syndrome	Physical and mental strains endured by elite athletes might influence the onset and severity of their psychiatric disorder
Johnson (1995)	Regular and constant physical exercise	Participants who perform exercise to avoid the unpleasantness of guilt and anxiety which occurs when an exercise bout is missed	Assume traits of addiction
Paluska and Schwenk (2000)	Habitual physical exercise programme interrupted	Participants with dysphoria	Effects on mental health
Heidary et al. (2011)	Aerobic exercises	Participants mainly doing aerobic exercises	↓ Stress level + better ability to control stressful conditions
Hoffman and Krouse (2018)	Excessive physical exercise	Participants were asked if ultramarathon was bad for their health	↓Of appetite and ↓ food intake (real active anorexia) leading to the phenomenon of "self-starvation", i.e., death caused by lack of food
De Giorgio et al. (2018);	Anaerobic activities (yoga)	Participants with non-specific chronic low back pain were investigated for anxiety, kinesiophobia and pain	+ Effects on psychological indexes related to anxiety, kinesiophobia, pain
Kuvačić et al. (2018)	Anaerobic activities (yoga)	Participants with chronic low back were investigated for disability, anxiety, depression, and pain	+ Effects on psychological indexes related to depression anxiety, pain, and life quality perception
Telles et al. (2019)	Anaerobic activities (yoga)	Participants working in occupations requiring vigilance	Sleep improvement ↓Anxiety while increasing vigilance.

Legend: +: positive; ↓: decrease; -: negative

Hypnosis, motor visualization, and relaxation techniques

Research proved that intense physical effort could be the origin of a panic attack, thus leading Morgan (1995) to consider self-control of the effort and exercise intensity as a possible solution to the problem of excessive fatigue in the field of sport diving. Techniques, such as hypnosis, motor imagery, and relaxation, are accurately reported by Morgan et al. (1995) (summary findings presented in Table 2); in particular, hypnotic suggestion seems to be extremely effective in creating ideal psychophysiological conditions for relaxation, creating a hypometabolic state (Garvin et al., 2001; Young & Taylor, 1998). An alteration of cardiovascular responses was reported when subjects at rest underwent suggestions related to the performance of physical exercise (Wang & Morgan, 1992). These responses were even proportional to the intensity of the effort suggested during the hypnotic session.

Metabolic and cardiovascular effects of hypnotic suggestion techniques were then compared with those obtained with the techniques of motor imagery (Conroy & Hagger, 2018). Motor imagery and real physical exercise seem to have the same neural mechanism of motor programming (Holmes & Calmels, 2008; Moran et al., 2012). Furthermore, it was observed that during an imagined sequence of movements, the activation of the cortical areas in charge of body movement is similar to what is observed during the real execution of the same sequence of movements (Holmes & Calmels, 2008). Based on these results, experts suggest addressing research to analyse specific features of subjects that use this technique to identify differences in the imaginative ability and in the preference of one technique over another to improve the desired sports performance. Regarding relaxation techniques, most studies point out that subjects more prone to anxiety have a higher probability of experiencing respiratory disorders (Morgan, 1995), which is the starting point of most relaxation techniques. However, several studies emphasize the concept that anxiety leads to better performance in many athletes; consequently, the application of these techniques is not appropriate (Silva, 1990). This concept is represented by the distinction between positive or performance stress (eustress) and counterproductive or performance undermining stress (distress). Thus, specific relaxation exercises should be useful when symptoms of anxiety lead to avoidance of physical exercise.

In sport divers, lower respiratory frequency is associated with better performance (Griffiths et al., 1981; Morgan, 1995). On this topic, Bachrach and Egstrom (1987) reported that breathing could represent a fundamental signal in recognizing the stress level of athletes. Therefore, the psychophysical monitoring of divers by personnel from the surface is principally concentrated on the respiratory rate. However, this does not imply that there is necessarily a causal relationship between breathing and performance and, thus, the training of these athletes should aim to reduce the respiratory frequency. In contrast, reducing the respiratory frequency could be useful in subjects with panic disorder, for whom breathing control has been proven to have a significant influence. Starting in the 1970s, research in the treatment of panic disorder included the development of techniques based on respiratory frequency control (Lum, 1976). A study conducted by Clark, Salkovskis, and Chalkley (1985) at the Department of Psychiatry of Oxford University, was organized into three phases: 1) the subjects suffering from panic disorder were asked to perform voluntary hyperventilation in order to provoke a mild panic attack; 2) the subjects were then explained the physiological effects of this over-breathing in order to let them associate the cause of their panic attacks to the hyperventilation related to stress rather than catastrophic phenomena, such as heart attacks, epilepsy, or mental diseases; 3) the subjects were finally trained to control their breathing using proper techniques for managing the hyperventilation related to stressful situations. After two weeks of treatment, the result was a substantial reduction of the frequency of panic attacks related to conditions usually considered as stressful, with a further improvement, respectively, after six months and two years after the beginning of the treatment. The efficiency of hyperventilation in panic disorder has also been confirmed by recent literature (Meuret & Ritz, 2010; Wollburg et al., 2011).

Table 2. Summary findings of different approaches and their functions

Study	Type of technique	Functions
Clark et al. (1985)	Techniques based on respiratory frequency control	Reduction of the frequency of panic attacks related to conditions usually considered as stressful after two weeks of treatment, with a further improvement, respectively, after six months and two years after the beginning of the treatment
Wang and Morgan (1992)	Hypnosis	Alteration of cardio-vascular responses proportional with the intensity of the effort suggested during the hypnotic session
	Motor visualization	Increase in the area of cerebral blood flow when subjects are led to imagine handling a tennis racket and hitting a ball on the wall
Morgan (1995)	Relaxation techniques	Higher probability of experiencing respiratory disorders in subjects more prone to anxiety
Young and Taylor (1998)	Hypnosis	Create ideal psychophysiological conditions for relaxation, turn into a hypometabolic state
Holmes and Calmels (2008)	Motor visualization	Similarity in the activation of the cortical areas in charge of body movement between this technique and to what was observed during the real execution of the same sequence of movements

Physical activity and mindfulness

The term "mindfulness" represents a group of mental techniques that aim to achieve a mental state characterized by knowledge and acceptance of each thought, feeling or emotion in the specific instant in which they are experienced (Baron et al., 2013; Ludwig & Kabat-Zinn, 2008) (summary findings presented in Table 3). Gardner and Moore (2007) called it Mindfulness-Acceptance-Commitment (MAC), enlightening the aspect of the subject's acceptance and commitment of present instant feelings. The mindfulness techniques were developed for treating subjects with chronic diseases (Farver-Vestergaard et al., 2018; Grazzi et al., 2017), but then they were successfully applied in the field of psychiatry for the treatment of anxiety and depression disorders (Zhang et al., 2015; Zhang et al., 2019), and then were adapted and structured as innovative models based on understanding and acceptance of one's state of health (De Giorgio et al., 2017; De Giorgio et al., 2017; Gulotta et al., 2015; Padovan et al., 2018; Padovan et al., 2018). Considering that mindfulness is focused on the present moment, it seems particularly intended for athletes, as for their constant need to concentrate on a specific task related to the exercise they are doing. For this reason, there is an analogy between these techniques and the mental state of "flow", defined by a Hungarian psychologist Csikszentmihalyi (1977), frequently translated in the sport field as agonistic trance. It refers to an experience characterized by the athlete's total involvement in a specific exercise, focusing on the target result until being pulled away by a flux or a water stream (Swann et al., 2017). Due to this involvement, the result of this experience is particularly positive and gratifying.

The mindfulness techniques have origin in millenary Buddhist techniques and aim to achieve a state of wellness. The subject should selectively concentrate on "here and now", with an approach free from any judgment and with acceptance for the lived moment to obtain the result. It consists of creating space between perception and response, which makes the subject able to adopt reflective and reflexive behaviour. In the sport context, these techniques are associated with cognitive-behavioural therapy to be applied for treating anxiety disorders (Alsubaie et al., 2017). Breathing represents a primary component of mindfulness techniques. The athlete is asked to concentrate exclusively on his breathing. One of the most important aspects of breathing leading to relaxation is breathing through the nose, for the presence of nitric oxide (Chambers et al., 2001), which has bronchodilator and vasodilator effects, and because breathing helps to normalize the respiratory volume.

Different methods are proposed to keep stress and anxiety under control (Baron et al., 2013; Goodger & Broadhead, 2016). These techniques generally connect the application of respiratory techniques with mindfulness and concentration techniques. An example could be the "Wim Hof" method, a technique that was recently developed based on the personal experience of the Dutch world record holder Wim Hof, famous for his resistance tests at sub-zero temperatures, performed thanks to a series of advanced respiratory and meditation techniques developed over the years. Based on cycles of deep breathing alternating with apnoea phases, this method should permit a modification of body physiology thanks to the control of breathing. This technique has the aim of oxygenating the tissue and optimizing oxidation of the energetic substrates, determining the activation of thermogenesis. Researchers from the Wayne State University (Detroit, MI, USA) studied the Wim Hof method and recently published a study establishing that these techniques could be applied in the treatment of psychiatric disorders and autoimmune diseases (Muzik et al., 2018). This study hypothesized that the Hof ability should be related to increased sympathetic innervation and glucose consumption in intercostal muscles. The imaging techniques revealed that the Wim Hof meditation technique allows generating heat that is dissipated in the pulmonary tissue, controlling the blood flow temperature in the pulmonary capillaries. The researchers also hypothesized that human beings could generate an analgesic response to stress with the production and release of opioids and cannabinoids. This effect should have the power to induce a feeling of wellness and to control one's mood and anxiety. This process could also be applied in the field of psychiatry (Muzik et al., 2018).

In the sport context, it is important to stress that breathing and self-control techniques, although with physiological consequences, are based on cognitive-behavioural methodology, aimed to treat the symptoms and not the cause of the problem. In particular, relaxation techniques will not solve conflicts related to athletes' emotional or family problems that caused the anxiety disorder, but they will eliminate or reduce the impact of anxiety on athletes' performance. The relaxation techniques based on breathing control are particularly effective for controlling stress in the resumption of physical activity after injuries or accidents on the field (Reesee et al., 2012). The awareness that the athlete's psychology is not exclusively related to sports performance during training or competition but also to his whole life and personality has led to a more complex meaning of the term "performance". In this wider context, it will be necessary to include not only all the situations directly related to physical activity, such as the mental state of an athlete in the period of rehabilitation from an injury but also all those situations not directly related to agonistic activities (Ford et al., 2017).

Table 3. Summary findings of different mindfulness techniques and their functions

Study	Type of technique	Functions
Reese et al. (2012)	Relaxation techniques	Eliminate or reduce the impact of anxiety on athlete's performance
	Relaxation techniques based on breathing control	Effective for the control of stress in the resumption of physical activity after injuries or accidents on the field
Muzik et al. (2018)	Wim Hof method	Treatment of psychiatric disorders and autoimmune diseases
	Wim Hof method	Generate heat that is dissipated in the pulmonary tissue, controlling the temperature of the blood flow in the pulmonary capillaries

Conclusions

Most of the psychological literature regarding anxiety disorders in sports is principally related to the cognitive-behavioural aspects and rarely to other psychodynamic, narrative, humanistic, or existential approaches. Research in the field of sport psychology and psychiatry, going beyond the field of the physical body, does not have a clear epistemological address as organic medicine does. The scientific literature shows an association between breathing and panic disorder, even if a causal or unilateral relationship does not express this. An athlete has different options for recognizing a problem and dealing with it. In this context, sport, with proper awareness, starting as an originating factor of anxiety disorder, could become even a primary or preferential treatment. This result could be achieved with different techniques that involve rational breathing, mindfulness, or relaxation techniques that can contrast anxiety disorders and even improve sports performance.

Finally, research is also concentrated on interesting results regarding the use of oral protection appliances for improving sports performance by enhancing respiratory function, though the influence of these appliances on the athlete's psychopathological background is still to be investigated.

Further literature analysis of sports experience related to psychodynamic treatments could relieve an interesting scenario, while future reviews should focus on establishing the impact of the physio-psychological aspect in each kind of sport activity.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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