

Scuba diving and the stress response: considerations and recommendations for professional and recreational divers

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ABSTRACT

Scuba diving is an activity that people engage in both for recreational purposes as well as having professional, commercial, and military applications. Scuba diving has often been considered a high-risk activity but, overall, scuba diving has been shown to be a safe activity when divers participate within their experiential, physical, and psychological limits. However, increased physical and psychological stress can quickly arise during diving activities due to unexpected events and situations and may lead to the onset of panic in an unprepared diver. Dive safety is dependent on the ability of a diver to understand the primary signs of stress and panic and attempt to minimise their potential impacts on the immediate situation. The purpose of this review is to examine the stress response in divers, illustrate the role that panic plays in potential diving accidents and fatalities, and provide recommendations to both help understand and manage stress and panic in the diving community in an effort to further increase the overall safety of scuba diving across all applications.

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INTRODUCTION

Scuba diving has been a recreational activity since the early 1950s and continues to be a choice of activity for many avid divers across the globe. In addition to recreational scuba diving there are significant professional, technical, military, and commercial applications of the skills needed to be a successful and safe scuba diver. Although many individuals view scuba diving as a risky activity, when individuals are trained and follow common safety protocols, scuba diving has minimal risk associated with it [1, 2]. Competent and safe divers are usually highly skilled and trained by one of the major certifying agencies that oversee scuba diving certification. These agencies include the National Association of Underwater Instructors, the Professional Association for Diving Instructors, Scuba Schools International, as well

as others. These organizations have been developed to standardise dive training for individuals who want to engage in diving practices and learn the skills needed to be a safe scuba diver. Although these organizations differ in the classes that are offered and the methods of instruction, their overall goal is the same; to teach the necessary diving skills one may need to practice safe diving.

One of the major considerations when deciding to dive is determining one's overall physical condition and overall fitness levels. Although the actual act of diving is often considered non-strenuous due to its use of specific equipment and environmental considerations, diving can also become extremely strenuous under different circumstances. Changes in environmental conditions, equipment limitations, emergency situations, or sudden physical stress can

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immediately increase the metabolic demands of the diver. Without the necessary physical conditioning, these situations can quickly lead to increased physiological stress and are often a precursor to a cardiac event. Statistics suggest that cardiac events are one of the leading causes of injuries or fatalities within the diving population [2]. Additionally, over the past several decades significant research has examined the role that exercise and physical training has on diving injury or mortality rates across different ages and skill levels of divers [3, 4].

Along with the importance that physical exercise and conditioning activities play in dive safety and performance, psychological considerations are also an area that needs to be more closely addressed and examined in the research literature. Diving can be inherently stressful at times and this increase in stress, if not managed successfully, may lead to an increased risk of an accident or fatality. Increased stress affects both physiological performance (increased stress on the cardiorespiratory system, for example), as well as the mental performance of the scuba diver. Situations that lead to increased anxiety, physiological arousal, slow reaction time, and a loss in situational awareness may significantly impair the diver and lead to dangerous or catastrophic results. Thus, the goal of this paper is to address some of psychological considerations that one may need to evaluate before choosing to engage in scuba diving activities. In addition, a short review of the research that has examined psychology and diving will be described in an effort to provide information that can improve the overall safety and performance of the active scuba diver, regardless of the type of diving that one engages in or the overall level of training that one may have received.

STRESS AND THE SCUBA DIVER

Throughout the research literature, the term stress (or stressor) has had a lack of consistency in its definition and usage. Depending on the situation or experiences, the definition of stress may mean different things to different people. Historically, stress has been defined as “a nonspecific response of the body to any demand” [5]. However, this definition may be limited in nature. Stress can be referred to the physiological response of the body to a threat to its ability to maintain internal homeostasis [6]. This definition often focuses on physiological changes that occur due to some external stressor; these include alteration in heart rate, blood pressure, and respiratory rate. Other definitions have focused on the change in behaviour that occurs due to the cognitive processing of information that may be perceived as a threat [5]. These definitions have focused on the behavioural changes that occur when a person is faced with an external stressor, including avoidance of stressful situations [6]. For the purpose of this review,

stress will be defined as a process of physiological and behavioural change to an unpredictable or uncontrollable threat to one’s ability to manage a specific situation. In the case of the scuba diver, this may include environmental, physical, or cognitive changes that may disrupt the diver before, during, or after the completion of a dive.

Regardless of the definition that one may use to define stress, the stress response in a diver may lead to problems with the completion of a dive and potentially lead to a dangerous situation. When individuals are feeling increased stress, their observable behaviour may change from their “normal” behaviour to an altered form or pattern of movement. This change can often be observed and noted when trying to manage a stressful diver. According to Bachrach and Egstrom (1987) [7] there are multiple signs that a diver may be under increased stress. These include the following: excessive organizing behaviour, stalling, forgetfulness, increased rate of errors, perceptual narrowing, excessive use of humour, increased irritability, bravado, and superstitious behaviour. By understanding the specific signs of stress that a diver may display prior to or during a dive, one may be able to prevent a potential diving accident or fatality by helping that diver manage their stress or preventing that diver from continuing with a dive that they are unprepared to complete safely.

PANIC AND THE SCUBA DIVER

When divers are faced with unexpected or overwhelming external events, stress levels will elevate quickly and significantly. Uncontrolled stress management may lead to increased fear and, ultimately, panic in a diver unprepared to manage an unexpected diving situation. Throughout the scuba community, panic is considered to be the most dangerous outcome of increased stress and is one of the leading causes, or precursors, of many diving incidents and fatalities [8]. In scuba diving, panic is often the result of an unexpected situation or triggering event that hasn’t been previously experienced by the diver. Examples of situations that often lead to panic in divers include low gas reserves, disorientation, equipment malfunction, entanglements, exhaustion, and losing sight of an exit point [9]. Often times, panic leads to an uncontrolled emergency ascent to the surface while holding one’s breath during that ascent. Preventing the exhalation of gas while surfacing or ascending will lead to lung injury and often results in a fatal arterial gas embolism. Uncontrolled emergency ascents have been identified as the primary disabling event in many dive emergencies and accidents and need to be avoided at all costs [10]. By managing the stress response, divers will be better able to focus on the necessary skills for a successful and safe emergency ascent and will be less likely to forget significant skills,

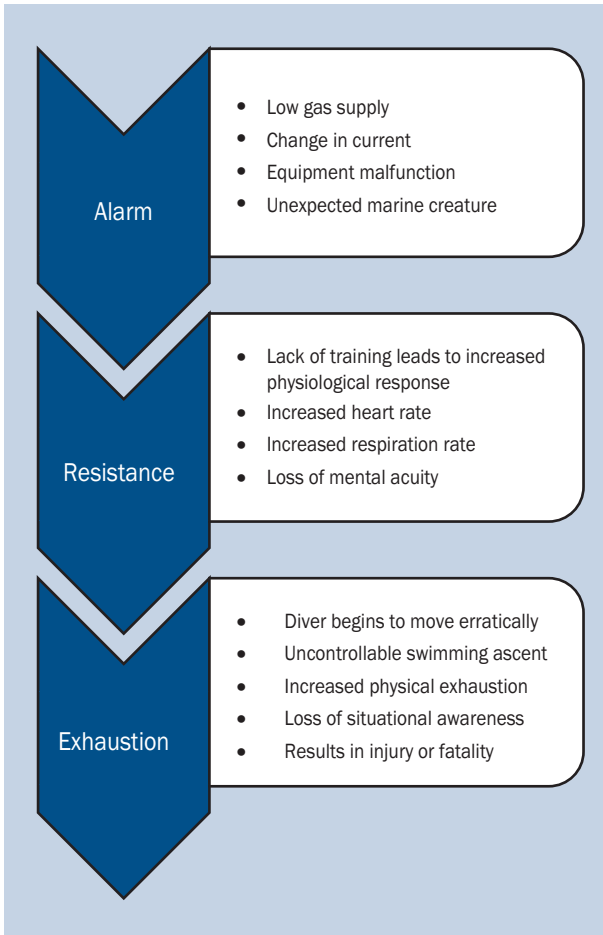


Figure 1. Stages of stress

such as continuous exhalation during ascent, which result in injury or death.

Panic is an example that is used to illustrate the generalised adaptation syndrome that has been examined in the psychological literature and applied stressors associated with scuba diving scenarios [7]. This reaction includes three distinct stages, including alarm, resistance, and exhaustion (Fig. 1). During the alarm stage, the diver is presented with a stressful situation or stimulus, such as a change in current or sudden appearance of a dangerous marine animal. This leads to the resistance stage in which the diver may try to manage this situation, but often in an uncontrolled or poorly directed manner; the diver may start to swim erratically or randomly reach for pieces of both necessary and unnecessary dive equipment. The continued physiological effort to manage the stressful situation, as well as the excessive energy expenditure that the panicked diver uses, may potentially leads to the exhaustion phase and the diver may become extremely tired and unable to maintain a particular depth or ascend to the surface safely. Particular to aquatic activities, exhaustion can result in severe injury or death due to the inability to remain buoyant

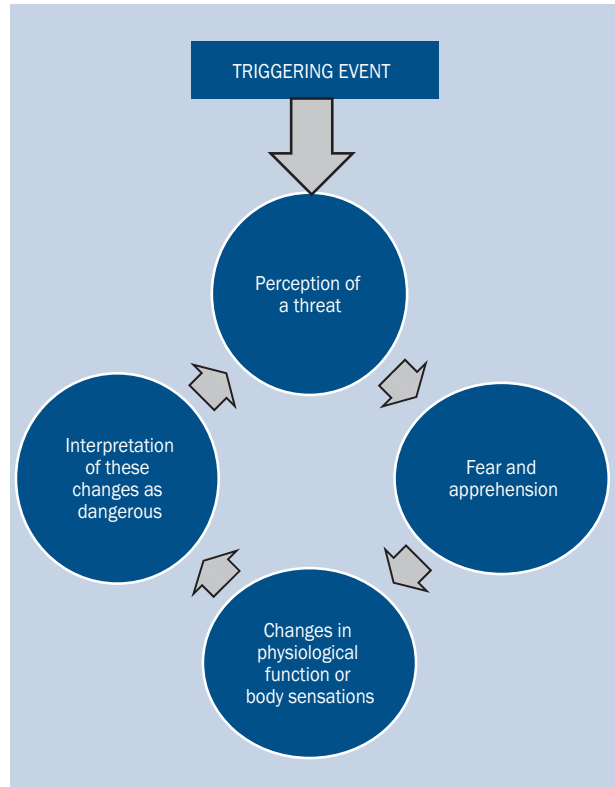


Figure 2. Threat response

in the aquatic environment and may lead to drowning. Panic can also be described as a cycle, or sequence of events and psychological and physiological responses to those events, which begins with a particular trigger or set of triggers (Fig. 2). This triggering event may lead to a diver feeling that their safety is threatened and lead to an increase in fear. Due to this sudden change, physiological functions such as an increase in heart rate and blood pressure may occur, along with changes in mental focus and acuity. These sudden changes may then be perceived by the diver as negative and potentially life threatening and increase the perception of threat to the diver. If this cycle is not interrupted, panic may quickly occur and unless managed immediately and effectively, these events can quickly lead to a catastrophic outcome such as a diving accident or death.

Panic is not uncommon in scuba diving. Morgan [8] conducted a national survey of scuba divers in the United States and the results of that study indicated that panic occurs in divers of various ages and experience levels. Additionally, researchers suggest that increased levels of trait anxiety in divers is associated with increased incidents of panic in surveyed divers. Along with the behavioural effects of panic, severe stress also has a significant impact on cardiovascular performance. Increased stress leads to an increased activation of the sympathetic nervous system (fight or flight system). This increased activation results

in an increase is cardiorespiratory stress and may lead to a myocardial infarction (heart attack) or other significant cardiac events. Research by Buzzacott and Denoble (2019) [2] suggests that cardiac events are one of the leading causes of death in the diving population. Additionally, the diving population has been shown to be significantly older than the general population [11] and often less inclined to engage in physical fitness activities [3]. These combined risk factors may result in an increased chance of a cardiovascular event when faced with a stressful or panic-inducing situation. Thus, the goal of any trained diver should be to prepare for and manage any stressful situation in an effort to avoid this panic response, as well as develop and maintain an exercise programme designed to improve cardiorespiratory function.

Preventing the onset of panic is critical to managing increased stress during scuba diving activities. The primary method of trying to manage or prevent panic in divers is to continually train and gain more experience in scuba diving skills and methods necessary for safe diving. Often divers achieve a specific certification and once that has occurred do not continually train under various conditions or situations. The more training and experience a scuba diver has, the less likely they will have a panic response to a changing situation, either because they previously have been in a similar situation or have simply gained the self-confidence to manage a new unpredictable event. Within the greater diving community, more emphasis needs to be placed on lifelong learning and practice of diving-related skills. Although many scuba certifying agencies recommend continuing education and lifelong practice of scuba-related movements and skills, many divers choose to ignore these previously learned skills because of a false sense of mastery or overall ability.

In addition to significant and continuous dive training, maintaining an effective exercise program is necessary in an effort to manage panic. The importance of exercise and physical fitness has been well documented in the research literature and all persons choosing to engage in scuba diving activities should be strongly encouraged to maintain an exercise programme and overall healthy lifestyle [4]. Through improvements in cardiorespiratory and muscular fitness, divers can physically manage stressful situation more effectively and with greater confidence. As previously stated, increased stress and panic results from one's perceived inability to manage unexpected situations and environmental conditions. Often times when diving, those situations are the result of changes in water current, unexpected surge, or potential separation from boats or other dive exit point. Under these circumstances, the stressed diver is forced to exert greater physiological effort to manage the situation (i.e. get back to the boat, swim against the current, etc.). Divers with greater cardiovascular reserves, resulting from structured exercise and conditioning programmes, will have both

the physical means, as well as self-confidence, to manage these unexpected events more easily and manage potential stress more effectively, thus preventing the onset of panic.

Two often overlooked considerations when trying to examine stress and the panic response in a diving situation is the level of both environmental awareness and self-awareness of the diver, both towards themselves and the external environment. In the opinion of this author, both environmental awareness and self-awareness should be key components of any discussion of the necessary abilities and skills needed to manage a stressful aquatic situation. Endsley [12] has defined situational awareness as the "perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and a projection of their status in the near future". More simply, it may be defined as an appropriate awareness of a situation [13]. Poor situational awareness has been associated with a significant number of airline accidents in the aviation industry and is thought to be a significant precursor to the onset of uncontrollable events [14]. While diving, situational awareness is key to a safe and successful dive. A scuba diver should practice the necessary skills needed to improve situational awareness and learn to manage how one needs to continually shift their focus and attention during a dive. Attentional capacity is limited in the human being [15] and a good diver must learn how to manage those limitations and attentional focus while scuba diving. Specifically, a diver needs to monitor multiple aspects of the dive at all times, including environmental changes that occur in the water, such as tides, current, or depth. Additionally, a diver needs to maintain constant awareness of gas supply, equipment configurations, hazards (including entanglement risks from kelp, fishing nets, or wreck sites), and their dive buddy. When one is unable to efficiently manage all this information during a dive and there is an unexpected change in one or more of these factors, increased stress occurs, and the onset of panic may not be far off.

By definition, self-awareness represents the ability or capacity of an individual to be the object of their own attentional capacities [16]. Self-awareness requires the individual to identify, neurologically process, and store information about the self. This ability is critically important to the diver; not only does a diver need to consciously attend to what is actively happening in the external environment but must also be consistently monitoring his or her own biological processes that may be altered due to being at depth. These include respiration rate, heart rate, anxiety levels, or just overall general body sensations. Any changes in these factors may immediately result in a change in breathing which in turn will alter the amount of breathing gas the diver has at their disposal. As unexpected drops in breathing gas during a dive is a common panic-inducing trigger, self-awareness

of one's physiological function and its' effect on respiration is a key component of safe diving practices.

RECOMMENDATIONS FOR THE ACTIVE SCUBA DIVER

As a diver becomes more familiar with stress and how it may present itself during a dive, what considerations or recommendations may be made to help prepare a diver and prevent the onset of panic? Are there training principles and protocols that may be used to manage stress and potential panic and how might those protocols be implemented into diver training?

As previously stated, one of the most important preventative measures that can be used to manage stress and panic during a dive is improved physical conditioning. All divers should participate in a structured exercise program that targets both cardiorespiratory and muscular endurance. Improved cardiorespiratory function will help the diver manage physiological responses to stressful diving situations and may help prevent a serious cardiac event. Another consideration regarding exercise and its role in managing diver stress are the normal physiological sensations associated with exercise. If a diver understands how the body reacts and the sensations associated with increased physical exertion, the diver is less likely to respond negatively to those sensations when they occur due to an external stressor while diving or in the water. Should a diver have an equipment malfunction and have a sudden increase in heart rate or respiration rate due to that sudden, unexpected stressor, they should be aware that this is a typical physiological response and will prevent any escalation into a panic event from occurring due to previous "comfort" and knowledge of those physiological changes.

In addition to improved physical fitness and conditioning, one of the most important ways to prepare for and manage stress and panic is continual training in the necessary skills needed for scuba diving. When individuals are first trained and certified, skills are practiced constantly and in many cases are overlearned. However, once divers successfully complete training and reach a desired level of certification, skill training and practice often are forgotten or minimally practiced. If a stressful situation occurs and the diver does not remember how to react, stress can increase exponentially and lead to the onset of panic. Therefore, it is highly recommended that divers continually practice the motor skills needed to manage unexpected situation. These skills may include equipment retrieval skills, buddy breathing, and signalling skills. This continued practice should lead to improvements in self-confidence and self-efficacy in a diver and allow for significant improvement in emergency management skills. From a practical perspective, it is recommended that divers begin and end every dive with a short practice session targeting skill retention in an effort to be prepared for the unexpected.

As part of a continuous learning and training program divers should also specifically focus parts of training on the practicing of the necessary scuba diving skills under differing conditions and environments. This refers to the specificity of practice principle that states practice should mimic the skills needed in competition (sport-related events) or real-world situations [17] and practicing under conditions of increased anxiety or arousal may have a positive effect on stress management during unpredictable conditions. Divers should train and practice their skills under differing conditions and environmental conditions. If a diver only trains under benign, predictable conditions, such as might be experienced under conditions of clear visibility and no current conditions, that diver will not necessarily be prepared for an incident under more challenging conditions that may present themselves while diving under low-visibility conditions. The more environmental conditions one has trained in and become comfortable with, the less likely an unexpected diving incident will cause uncontrollable stress and potential panic. The safe diver should always be looking to expand their training environments and practice under varying and moderately stressful conditions.

One final recommendation for the safe diver is to utilise a training mnemonic to visualise and focus during a dive emergency or unplanned event. In 2015, Kovacs [18] developed the A4 Principle as an assistive device for divers who are faced with an emergency situation. This principle focuses on four components; air, assess, acquire, and ascend, and was created to be used to recall what needs to be done while underwater and under stress. Air refers to the first principle for a diver; make sure you have immediate access to air or another breathing gas. Once breathing gas has been secured then the diver needs to assess the specific situation in an effort to plan for how to immediately respond. Following this step, the divers should then acquire what is needed (equipment, buddy assistance, etc.) to manage the situation. Finally, once the situation has been managed, the diver may ascend to the surface or alternative depth. This mnemonic does two things for the diver; it allows the diver to remember simple steps on how to handle an emergency in an easy to use format and by mentally focusing and paying attention on these four components during an emergency, the diver will not be able to overly attend to external stressors and potential stressful triggers, thus preventing the onset of a potential panic response. Dive training should include this or similar teaching and learning tools to improve diver safety and help them mentally prepare for a stressful emergency event.

CONCLUSIONS

Stress and panic are two significant considerations that every scuba diver should be aware of and make an effort

to manage during diving activities. There are multiple signs that indicate increased stress that may be occurring during a dive and lead to a potential panic response. Through proper management of triggers and stressors safe scuba divers are able to better handle unpredictable and stressful conditions and create a safer diving experience. In addition, there are multiple training and practice recommendations [18] for scuba divers that can be utilised in an effort to better prepare for potential stress. These include both physical and psychological training methods designed to improve physiological responses to stressors and mental conditioning for unpredictable situations through regular practice of the necessary skills needed for diver safety. Scuba diving can be a safe and relatively risk-free activity when scuba divers train and prepare effectively to manage unexpected situations and continued engagement in training activities can lead to more efficient and stress-free diving in both the recreational and professional diving communities.

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