

THE PROBLEM OF EXPERIENCING ANXIETY AMONG DIVERS. EXPERIMENT IN HYPERBARIC EXPOSURE CONDITIONS

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ABSTRACT

The aim of the article is a review of psychological literature relating to the problem of anxiety in divers, where an emphasis is placed on the degree of mental adaptation of the individual to the underwater environment, primarily highlighting the trait of anxiety and the neuroticism of a person involved in a specific type of diving. The article presents selected reports from all over the world regarding research on anxiety in divers. Treating a high level of the indicator of anxiety as a predictor of panic anxiety reveals the importance of this trait in predicting the risk of an occurrence of diving accidents during the operation under water. In the own research presented in the article, the results on the levels of anxiety as a trait and a state in divers taking part in hyperbaric exposures indicate the fact that the majority of the examined divers have low levels of anxiety both as a trait and a state, which most probably indicates the good psychological condition of the examined divers.

Keywords: psychology of diving, anxiety in divers, anxiety level.

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INTRODUCTION

Polish literature on the psychological condition of candidates for diver training and divers themselves comprises few studies, in either theoretical, research, or practical terms, with content indicating the importance of psychology. Only a few authors [1,2] stress that for candidates preparing for diving service, separate psychological tests, taking into account diving's specific characteristics, should be developed. In the era of economic calculation of training costs, the possibility of introducing additional psychiatric and psychological examinations prior to the commencement of diving should be considered. It is important to select people with a positive attitude towards this type of service from among the candidates. "Early identification of candidates lacking the correct emotional state will allow to reduce the costs of training for those who will not be able to perform well in the future" [1].

The above quotation contains a thesis that the authors understand that people employed to work in an underwater environment operate in an extreme context in terms of occupational health. They experience unique dynamics of the hyperbaric environment, with its physiological, psychological and social aspects, which constitute a serious and potential risk to their health and safety. For this reason, the scientific reports on anxiety issues presented in the article, as well as own research, are part of the theoretical and empirical psychological research, which may lead to the implementation of preventive and diagnostic actions to avoid negative effects on divers health.

The current knowledge on the effects of anxiety as a characteristic/state on the behaviour of divers is already well documented in world literature [3-14], and the five decades of research in the area of determining optimal personality profiles of divers, especially military divers, and treating the high anxiety index as a predictor of panic anxiety, indicate the importance of this parameter in predicting the risk of a diving accident [15]. The individual's time in different physical conditions during a dive is undoubtedly connected with changes in the mental experiences of the diver, which are determined by situational factors (water environment), and the individual's personality dispositions, including, above all, their level of neuroticism [13,15].

The theoretical perspective on which the aforementioned research is based (personality - as a set of constant traits) approaches human nature from the perspective of coherent and permanent individual differences, while personality traits are defined as having an impact on characteristic behavioural patterns. According to Ryckman [16] personality is a dynamic and organised set of qualities possessed by a person that uniquely influences his/her beliefs, motivations and behaviours in various situations. This explanation is consistent with the assumption that there are similarities between people, and yet each of us has specific characteristics that distinguish us from all others.

Over the last decades, the five factor model (the Great Five) has dominated the diver profile research, among which, according to the researchers, neuroticism is an important predictive factor [17]. In the diving study conducted by Mus et al. [18] it was found that neuroticism and amicability are two significant predictors of divers'

behaviour among the five personality traits. It was found that highly amicable divers are more responsible underwater, while highly neurotic divers are more irresponsible.

In the traditional psychological perspective, it is known that people with a high level of "neuroticism" react more distinctly/stronger to stimuli in their environment. With time, they become emotionally unstable, worried, excited and sad [17]. Neuroticism does not necessarily refer to any psychiatric defect. Costa and McCrae [17] understood this dimension as negative affectivity or emotional instability. According to Colvard and Colvard [20] anxiety has a negative impact on recreational activity.

The Big Five model by Costa and McCrae is based on the observation that human personality traits can be reduced to five factors and all other traits fall within their scope [17]. In the theoretical meta-analysis of Charles H van Wijk [15], in the article Personality profiles of divers: integrating results across studies, the author analysing 19 studies (1970-2018) on the described personality traits/profiles (in similar theoretical assumptions and also using the Big Five Model) of military and sport divers, found that the results suggest extremely stable profiles of military divers over generations, with some exceptional differences resulting from national and cultural variables being observed. The general conclusion of the analysis is that military divers are characterised by a propensity for adventure, a strong sense of autonomy and, what is important for the considerations of this article, they have a low level of the anxiety-related trait.

In the research related to the determination of predictors of panic anxiety in divers, the researchers use in their analyses the concept of classification of anxiety into a state and a quality, which is well established from a psychological perspective [10]. Over the last dozen or so years, a number of questionnaires have been developed to determine whether a person is in a state of anxiety or has a trait of anxiety, understood as a readiness to respond to anxiety in a number of different situations. In Poland, the most commonly used is the scale of S.T. Charles Spielberger's anxiety [21].

In his concept, C. D. Spielberger referred to the research conducted by R. B. Cattell and L. H. Scheier in the 1950s [21]. According to Spielberger, the anxiety-state (A-state) is characterized by "subjective, consciously perceived feelings of anxiety and tension accompanied by activation or stimulation of the autonomous nervous system". A characteristic feature of A-state is its high variability under the influence of various threatening factors.

Anxiety-trait (A-trait) is defined by Spielberger as a theoretical construct meaning "a motive or acquired behavioural disposition that makes an individual susceptible to perceiving a wide range of objectively harmless situations as threatening and responding to them with states of anxiety that are disproportionately strong in relation to the degree of objective danger". This definition emphasises the learned nature of fear. The formation of an anxiety personality is linked by Spielberger to the early childhood, the relationships between the child and the parents in this period, and especially to situations of disciplining the child.

A study conducted by van Wijk [10] (using Spielberger's State-Trait Personality Inventory) on 322

underwater specialists working in stressful conditions (aged 19-52, representing a variety of races) revealed a low profile of anxiety as a trait. Moreover, all candidates for divers with a low level of anxiety as a trait completed specialist training as compared to those with a higher anxiety-trait level. The author suggests that the scale of anxiety-trait should be used and implemented in the annual research for this group of professional divers, as the measurement of anxiety trait was stable over time, which suggests that when the results for this group of professionals are monitored, deviations from previous results may indicate a potential need for referral to intervention by health care professionals. The use of the anxiety-trait subscale in the supervision of underwater professionals can help prevent accidents by identifying high-risk candidates during yearly health assessments and directing them to temporary intervention.

A study review by van Wijk showed that anxiety is a reliable predictor of predisposition to experience panic during diving [10]. In particular, individuals with anxiety-trait equal to or higher than the average population are particularly at risk of an occurrence of panic anxiety. Anxiety-trait is additionally associated with susceptibility to injury during military diving training. Overall, research results [10] indicate that professional and recreational divers score low on the measure of anxiety as a trait.

In Poland, research on divers' anxiety experiences was conducted by the Department of Theory of Swimming Methodology at the Academy of Physical Education and Sports in Gdańsk [22]. The research group consisted of 30 divers (including 13 women) aged 14-44, who at least possessed Open Diver qualifications in the PADI organization. The aim of the analysis was to determine the level of anxiety-state and anxiety-trait in recreational divers.

The authors of the experiment searched for answers to three research questions. The first one concerned the availability of divers to experience anxiety related reactions. The second question was related to the occurrence of the relationship between anxiety-state and anxiety-trait in the studied divers. The third problem concerned the relationship between the age and sex of divers and the level of experienced anxiety. The results showed that every third respondent had a low level of anxiety understood as a trait and almost half of the respondents felt a strong state of anxiety. The age of the respondents did not influence the level of experienced anxiety both as a state and a trait. Moreover, the authors found significant differences between the level of experienced anxiety and the gender of the respondents. Women experience the A-state much more strongly than men. This indicates a higher probability of anxiety when faced with an unexpected situation in women-divers.

In a study by Morgan and his collaborators [23], the A-trait was determined for students of the elementary diving course. Students with high A-trait levels were significantly more likely to react with panic when practicing underwater tasks with an instructor. Such a correlation was found in 83% of the 42 examined candidates for divers. The authors point to the STAI test as a reliable tool to measure anxiety. Objective measurement of anxiety as a trait and a state in their opinion allows to predict the possibility of panic behaviours in beginner divers.

The correlation between the level of anxiety-state and the diving conditions was the subject of a study

by Koltyn, Shake and Morgan [24]. The subjects in the experiment swam 4 times for 30 minutes under the surface of water in the following conditions: a) in warm water (29°C) without a wet suit; b) in warm water in a wet suit; c) in cold water (18°C) without a wet suit; d) in cold water in a wet suit. The group of researchers proved that a significantly higher A-state level, accompanied the performance of tasks b) and c), which indicates the influence of thermal discomfort on experiencing anxiety.

The levels of stress, anxiety-state and anxiety-trait, the ways of coping with stress and a sense of control in freediving sportsmen were the subject of research by scientists from Atılım University İncek Gölbaşı in Ankara, Turkey [25]. The study investigated 36 freediving athletes and 41 non-sportsmen. The main feature of breath-holding diving, which distinguishes it from other sports, is the performance of sportsmen under water and the associated physiological and psychological limitations of the diver. In the cited studies, the level of stress, A-state and A-trait, positive and negative emotionality were qualified as situational psychological factors, and the styles of coping with stress and the location of control as stable psychological factors. The results of the study confirmed that athletes showed a lower level of anxiety-state, and a lower level of stress generally in contrast to those not practicing any sports. Sportsmen who breath-hold dive also achieved significantly higher results in terms of control localisation and stress management styles. Researchers stress that diving whilst holding ones breath has a positive effect on both situational and stable psychological traits.

Professional deep diving results in periods of long-term enclosure in hyperbaric chambers and exposure of divers to high pressure. French researchers have shown [26] that such extreme environmental conditions cause acute anxiety reactions only in some divers. The results confirm that diving related anxiety remains at an individual and relatively transitory level and suggest that personality factors such as low self-control and emotional instability, which reflect the inability to control and express tension in an appropriate way, played a key role in the occurrence of anxiety in some divers.

Another study [27] assessed the emotional stability of 6 male U.S. Navy volunteers during a 32-day dive in a chamber in absolute atmosphere (ATA) of 49.5. Each diver provided a self-reported description of moods and recorded complaints about pain. The study also monitored adrenaline, norepinephrine, 11- and 17-hydroxycorticosteroid (OHCS) levels prior to and in 10 intervals during the dive. The mood inventory showed a significant increase in fatigue and hostility at 49.5 ATA, accompanied by a decrease in perceived well-being. The divers reported the least pain while subjected to maximum pressure, whereas high frequency of pain occurred during compression and decompression. Urine concentration of 17-OHCS was significantly associated with anxiety and mood disorders, and epinephrine levels correlated significantly with anxiety scores. The most stressful parts of diving were the periods immediately preceding the achievement of maximum blood pressure and 1 ATA (surface).

OWN RESEARCH

The aim of the presented research was to answer the research questions:

- What is the level of anxiety as a trait in the studied divers?
- Is there a relationship between the experience of anxiety by the examined persons (divers) as a state and the depth of diving simulated during the air hyperbaric exposures, corresponding to diving at a depth of 30 m and 60 m and after the ascent?
- Is there a connection between the fear experience of the examined persons (divers) as a trait and as a state and their experience in practising diving?

The level of anxiety was studied with the STAI questionnaire - Anxiety State-Trait Personality Inventory, whose authors were C. D. Spielberger, R.L. Gorsuch, R.E. Lushene (in the Polish adaptation the authors are C.D. Spielberger, J. Strelau, M. Tysarczyk, K. Wrześniewski [21]). In order to collect demographic variables, a questionnaire was used containing questions about age, place of residence (city, village), education, occupation, marital status, diving experience.

In the second cycle, the STAI (X-1) Anxiety-State test was performed, during an exposure in a hyperbaric chamber at a depth of 30 m and after an exposure in a chamber at a depth of 30 m, and during the third cycle, the STAI (X-1) Anxiety-State test was used during an exposure in a hyperbaric chamber at a depth of 60 m and after an exposure in a chamber at a depth of 60 m.

The research was conducted in the habitat of the DGKN-120 Department of Underwater Work Technology of the Naval Academy in Gdynia. Short-term simulated air hyperbaric exposures corresponding to dives at depths of 30 and 60 metres were carried out. The exposure corresponding to diving at a depth of 60 metres was selected as it is the maximum allowable diving depth using air as a breathing mixture and 30 metres as half of the maximum depth.

The use of a hyperbaric chamber allowed to create comparable exposure conditions for all subjects, taking into account the utilised breathing mixture, physical effort and ambient temperature. In the hyperbaric chamber, air was used for breathing during

diving. Exposures were based on Navy tables of diver decompression and recompression from 1982. The exposition was carried out by compressing the subjects examined in a hyperbaric chamber to a pressure of 400 kPa, corresponding to a dive at a depth of 30 metres and to a pressure of 700 kPa, corresponding to a dive at a depth of 60 metres and staying at that pressure for 35 minutes.

During the exposure, the following environmental parameters were monitored and recorded in the habitat: total pressure, oxygen partial pressure, carbon dioxide partial pressure, nitrogen partial pressure, temperature and humidity in the chamber. After exposure at 30 meters, the decompression profile was applied as for diving at 33 meters, which corresponds to 440 kPa, and after exposure at 60 meters - as for diving at 63 meters (735 kPa). This is a customary procedure.

Psychological research included a group of 57 divers. All persons gave their voluntary and conscious consent to participate in the study, which was approved by the Bioethics Committee of the Military Medical Institute No. 7/WIM/2016.

RESEARCH RESULTS

In the course of the research process, a number of statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS) for Windows, version 24.

In order to verify the differences between the mean levels of anxiety-state, the following analyses were carried out. Due to the lack of normal distribution of the majority of results obtained from the STAI Questionnaire, the analysis of variance of repeated measurements for Friedman's ranks (ANOVA Friedman), i.e. non-parametric equivalent of one-way variance analysis with repeated measurement, was applied. Data exploration showed a significant difference in the levels of anxiety as a state depending on the baric exposure ($\chi^2(4, N=57) = 14,14; p < 0.01$). In order to gain a better understanding of the described effect, additional post hoc analyses were carried out using the Wilcoxon test, with Bonferroni correction and the resulting significance level of $p < 0.01$. None of the comparisons showed any significant differences.

Tab. 1

Mean values for anxiety as a state calculated into stens.

		Stai_sten_stai_x_1	Stai_sten_na_30m	Stai_sten_po_30m	Stai_sten_na_60m	Stai_sten_po_60m
N	Significant	57	57	57	57	57
	No data	0	0	0	0	0
Mean		3.6140	3.4737	3.4737	3.4561	3.0175
Standard deviation		1.75004	1.93746	1.69142	1.66980	1.96842

Tab. 2

Mean results for anxiety perceived as a trait and a state – raw results.

		Stai_przed_x_1 trait	Stai_przed_x_2 state	Stai_na_30	Stai_po_30	Stai_na_60	Stai_po_60
N	Significant	57	57	57	57	57	57
	No data	0	0	0	0	0	0
Mean		30.60	32.28	30.33	30.67	29.91	28.68
Standard deviation		5.775	5.003	7.172	6.289	5.896	6.830

In the study group, the mean level of anxiety as a trait amounted to 32.28 (SD = 5.00), while the mean level of anxiety as a state was 30.61 (SD = 5.78). In order to compare these scales, the raw results were converted into sthene values, which reached respectively: M = 3.21; SD = 1.1 and M = 3.61; SD = 1.75. The r- Pearson correlation analysis showed a strong positive relationship between the tested variables ($r = 0.547$; $p < 0.001$). It can therefore be concluded that with the increase in the level

of anxiety as a trait, the level of anxiety as a state increases.

Results of anxiety measurements as a state with consideration of allocation to groups

STAI results according to groups:

1. low: 1- 4 sten,
2. medium: 5 - 6 sten,
3. high: 7 - 10 sten.

Tab. 3

Distribution of Stai results for anxiety-trait divided into groups: high, medium, low level.

		Frequency	Percent	Percentage of significant	Accumulated percentage
Significant	low (1 - 4)	47	82,5	82,5	82,5
	medium (5-6)	9	15,8	15,8	98,2
	high (7-10)	1	1,8	1,8	100,0
	Total	57	100.0	100.0	

Tab. 4

Distribution of Stai results for anxiety-state – Measurement 1.

		Frequency	Percentage	Percentage significant	ofAccumulated percentage
Significant	low (1 - 4)	35	61.4	61.4	61.4
	medium (5-6)	20	35.1	35.1	96.5
	high (7-10)	2	3.5	3.5	100.0
	Total	57	100.0	100.0	

Tab. 5

Distribution of Stai results for anxiety-state – Measurement 2 at 30m.

		Frequency	Percentage	Significant percentage	Accumulated percentage
Significant	low (1 - 4)	42	73.7	73.7	73.7
	medium (5-6)	12	21.1	21.1	94.7
	high (7-10)	3	5.3	5.3	100.0
	Total	57	100.0	100.0	

Tab. 6

Distribution of Stai results for anxiety-state – Measurement 3 after 30 m.

		Frequency	Percentage	Percentage significant	ofAccumulated percentage
Significant	low (1 - 4)	41	71.9	71.9	71.9
	medium (5-6)	14	24.6	24.6	96.5
	high (7-10)	2	3.5	3.5	100.0
	Total	57	100.0	100.0	

Tab. 7

Distribution of Stai results for anxiety-state – Measurement 4 at 60 m.

		Frequency	Percentage	Percentage significant	ofAccumulated percentage
Significant	low (1 - 4)	37	64.9	64.9	64.9
	medium (5-6)	19	33.3	33.3	98.2
	high (7-10)	1	1.8	1.8	100.0
	Total	57	100.0	100.0	

Distribution of Stai results for anxiety-state – Measurement 5 after 60 m.

		Frequency	Percentage	Percentage significant	ofAccumulated percentage
Significant	low (1 - 4)	43	75.4	75.4	75.4
	medium (5-6)	9	15.8	15.8	91.2
	high (7-10)	5	8.8	8.8	100.0
	Totoal	57	100.0	100.0	

- Differences in the number of people with low, medium or high Stai scores - the trait is confirmed by the analysis performed using the non-parametric chi2 test ($X^2(2, N = 57) = 63.58; p < 0.001$).
- Differences in the number of people with low, medium or high Stai scores - state - first measurement confirmed by analysis performed using non-parametric chi2 test ($X^2(2, N = 57) = 28.74; p < 0.001$).
- Differences in the number of people with low, medium or high Stai scores - state - second measurement at 30m is confirmed by an analysis performed using non-parametric chi2 test ($X^2(2, N = 57) = 43.9; p < 0.001$).
- Differences in the number of people with low, medium or high Stai scores - state - third measurement after 30m is confirmed by an analysis performed using non-parametric chi2 test ($X^2(2, N = 57) = 42; p < 0.001$).
- Differences in the number of people with low, medium or high Stai scores - state - fourth measurement at 60m is confirmed by an analysis performed using non-parametric chi2 test ($X^2(2, N = 57) = 34.11; p < 0.001$).
- Differences in the number of people with low, medium or high Stai scores - state - fifth

measurement after 60 m is confirmed by an analysis performed using non-parametric chi2 test ($X^2(2, N = 57) = 45.9; p < 0.001$).

The presented results of statistical analyses provide the basis for the conclusion that the examined divers experience anxiety, described as a state at the depths of 30 and 60 meters and, following such exposures, at a low level. Also, the results concerning anxiety as a trait indicate that the examined divers are characterised in most cases by its low level. Moreover, the analysis revealed that the average level of anxiety as a state does not differ in the subjects in particular conditions of hyperbaric exposure, both at dives at 30 and 60 meters and after emergence from these dives. It is worth noting that in the studied group of divers there are individuals with a high level of anxiety as a state, most people (5) experience it after decompression from a depth of 60 meters.

The results of the analysis concerning the relationship between the diving experience of the examined persons and the state of anxiety in particular conditions of the experiment are presented in Tables 9 and 10.

Tab. 9

Diving experiences (in years).

N	Significant	No data	Mean	Standard deviation	Minimum	Maximum
57		0	10,1228	5,51320	2,00	28,00

Tab.10

Results of the analysis on the relationship between diving experience and anxiety-state/trait in the experimental conditions.

	Stai_before_x_1trait	Stai_before_x_state	Stai_at_30m	Stai_after_30m	Stai_at_60m	Stai_after_60m
Chi-square	2.879	2.799	1.265	.667	2.044	3.816
df	2	2	2	2	2	2
Asymptomatic significance	.237	.247	.531	.716	.360	.148

a. Kruskal-Wallis test

b. Categorical variable: Diving experience (in years)_rec

Analysis using the nonparametric chi² test showed no correlation between diving experience and the level of anxiety as a trait/state in relation to the conditions of hyperbaric exposure.

DISCUSSION

In the presented study, the obtained results on the level of anxiety as a trait and state in divers taking part in hyperbaric exposures are similar to the findings quoted in the introduction to the article [4,7,10,15]. Special attention should be paid to the fact that the majority of the subjects exhibit low levels of anxiety trait/state, which most likely proves the good psychological condition of the divers. A high level of anxiety would undoubtedly become an obstacle to functioning in natural underwater conditions and, as the researchers point out, it would be most likely the basis for the occurrence of panic anxiety in the future. Among 57 divers, one person had a high level of anxiety as a trait, which, according to van Wijk [10] exposes the subject to the risk of a diving accident. Undoubtedly, it should be stated that the study on the level of anxiety-state in "artificial" conditions of a hyperbaric exposure does not take into account many environmental factors that affect the formation of situational anxiety in natural submersion. Nevertheless, the controlled conditions of compression and decompression confirm the conviction that the divers under study are most likely to implement learned strategies for dealing with pressure changes that do not pose a psychological threat to them.

The lack of correlation between diving experience and anxiety trait/state in different conditions of hyperbaric exposure obtained in the analysis is an interesting result. It appears that the mechanism of coping with anxiety most likely does not result from the number of years of experience in diving, but from other personal predispositions, such as high self-control and emotional stability, as indicated by the quoted French researchers [26], which help to reduce/control and appropriately express tension.

CONCLUSIONS

Determining the level of anxiety in conditions physically different from natural conditions for divers should contribute to the prevention of hazardous situations under water. In this study, the divers were found to have a low level of anxiety as a trait, and experimental situations did not induce a high level of anxiety as a state. Based on the observations of the quoted authors, it can be assumed that early diagnosis of anxiety states in divers will help to predict their behaviour underwater. Diving training centres should collaborate with psychologists who have the authority to apply and interpret psychological tests. It is proposed that in order to help explain the mechanism of coping with anxiety in the natural underwater environment, further research be carried out in to the recognition of psychological dispositions of individuals.

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