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HPNS effects among 18 divers during compression to 360 msw on heliox

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Værnes RJ, Bergan T, Warncke M. HPNS effects among 18 divers during compression to 360 msw on heliox. Undersea Biomed Res 1988; 15(4):241–255.—Heliox compression deeper than 16 ATA can lead to EEG changes associated with confusion and somnolence. In man the symptoms termed the high pressure neurologic syndrome (HPNS) can also include increased tremor, memory problems, dizziness, nausea, and vomiting. In a series of 3 dives at NUTEC, a compression profile developed for operational use down to 360 msw was evaluated. In each dive 6 different divers were compressed to 360 msw on heliox. Neuropsychologic and neurophysiologic testing were performed repeatedly. The HPNS testing revealed only mild effects of the compression. Only 3 divers had impairments of more than 2 SD in peripheral motor function compared to their predive average. Memory was impaired periodically in 2 divers. The same was found for perceptual speed and reasoning. Fifty percent of the divers had an increase of more than 2 SD in postural tremor, but that had minimal effect on their motor performance. Six of the 18 divers had an EEG power spectrum with both alpha band inhibition and theta increase. While the performance impairment was most marked around 240 msw, the EEG changes occurred mainly deeper than 300 msw. In only 1 of the 18 divers marked EEG changes, marked tremor increase, and marked cognitive performance impairment were observed at the same time. Although mild HPNS was observed, the divers were little impaired during the compression to 360 msw. The results confirm that using a compression profile with rates decreasing progressively with increasing depth, and with several intermediate stops, provides fit divers at depth. By using standard batteries of HPNS testing we were able to obtain evidence for the acceptability of this compression profile.

HPNS
EEG
tremor
performance
symptoms

When diving to pressures greater than 150 meters of seawater (msw) symptoms and signs of the high pressure neurologic syndrome (HPNS) may appear (1). The syndrome includes tremor of the hands and arms, increased EEG slow-wave activity (2–7 Hz) and depression of alpha waves (8–13 Hz), dizziness, nausea, and vomiting. At depths greater than 300 msw lapses of consciousness may occur (2). The symptoms of HPNS become more severe with increasing depth and during fast rates of compression.

Various methods have been used to ameliorate the signs and symptoms of HPNS, including selection of less sensitive divers, the use of excursions from a shallow saturation exposure, slow exponential compression with stops for adaptation, and the use of narcotics to antagonize the effects of HPNS (3). Studies of these methods have shown that the speed of compression correlates with the extent and intensity of the various symptoms (4–6). In particular, a slow compression interrupted by holding stages has been shown to reduce the HPNS considerably (7–10).

A major problem in evaluating the effects of HPNS by manipulating the compression conditions and/or selecting less sensitive divers is the individual variation in reaction pattern (11–13). While one diver may show a normal EEG but significant tremor followed by impaired motor performance, another diver may show normal motor functions but significant EEG changes accompanied by impaired cognitive performance. To study these different responses we recommend the use of a relatively comprehensive battery of tests for evaluating a compression profile. The validity of such a battery of tests can, however, not only be related to fitness at depth but also to the temporal aftereffects, which have been observed in deep diving (14). In a previous deep dive with fast compression a close relationship was found between fast Fourier transform (FFT)-EEG changes during compression and the postdive FFT-EEG (12).

A compression profile with holding stages and slower compression rate at deeper depth was developed for operational diving to 360 msw in the North Sea. During 1986, 3 manned, onshore, simulated dives were performed at NUTEC for an analysis of this profile. Eighteen professional divers (6 in each dive) participated. After predive training including recording of baseline levels, the divers were compressed to 360 msw.

METHODS

Subjects

The 18 divers were 6 navy divers from the British Royal Navy (dive 1) and 12 offshore divers from a Norwegian diving company. They were all trained in saturation diving procedures. The divers were required to be in excellent health. After 2 wk of predive training the subjects volunteered to participate after being fully informed about the dive program. They could withdraw from the experiments at any time.

The divers' previous saturation experience was from 4 to 500 d with an average of 120 d (1 SD = 84.6). The average total diving experience was 8.3 yr (1 SD = 2.1). The average weight was 77.8 kg (1 SD = 4.9) and the average height was 179.3 cm (1 SD = 17.0).

Experimental design

Test procedures

Testing during the training period. The test procedure was the same for all 18 divers. Predive trials of all tests were repeated 10 times at minimum during the

predive weeks to familiarize the subjects with the test procedures to be used in the pressure chambers and to reduce learning effects. Predive control values were calculated from the average of the last five samples for all variables.

Testing during the dive. During the compression the subjects rotated between different test stations. This rotation was repeated throughout the compression at fixed schedules. The test sessions occurred at 80 and 160 msw, on reaching and leaving 240 and 320 msw, and at 360 msw.

Environmental conditions

Compression profile. The profile is presented in Table 1. The compression rate was reduced by 50% between each intermediate depth starting with a rate of 3.0 msw/min to 80 msw and finishing with a rate of 0.167 msw/min (6 min/msw) between 320 and 360 msw.

Chamber temperature and humidity. During the compression the relative humidity stabilized around 55–60% in the evening of dive Day 1 where it remained for the rest of the compression. The chamber temperatures were around 27°C in both chambers at the start of compression, going up to 30.5°C. Temperatures varied between 29 and 31°C during the rest of the dive. Temperatures were acceptable according to tables by Bondi (15).

Breathing gas. The partial pressure of oxygen (P_{O_2}) was 0.48 and 0.50 bar at the start of compression in the two chambers. It varied between 0.47 and 0.60 bar during compression. On reaching 360 msw on dive day 2, the P_{O_2} was 0.47 bar. The CO_2

TABLE 1
THE COMPRESSION PROFILE

Depth, msw	Rate, msw/min	Travel Time, min	Stop Time, min	Total Time, min
0–15	3.0	5	—	5
15	—	—	20	25
0–80	3.0	27	—	47
80	—	—	60	107
80–160	1.5	53	—	160
160	—	—	180	340
160–240	0.67 (1.5 min/m)	120	—	460
240	—	—	480	940
240–320	0.33 (3 min/m)	240	—	1180
320	—	—	600	1780
320–360	0.167 (6 min/m)	240	—	2020

was below 300 particles per million (ppm), during the whole dive. The P_{N_2} was below 0.8 bar throughout the whole dive in the chamber complex.

Instrument description

The compression battery

The following 6 tests were administered repeatedly throughout the compression:

Electroencephalography. The recording system used for the EEG consisted of preamplifiers located in the chamber and amplifiers and filters outside. EEG electrodes were located at P3-F3 and P4-F4 according to the 10–20 system, to obtain bipolar EEG recordings from both hemispheres. Electrodes were fastened to a cap modified for each subject. Standard clinical procedures for obtaining the EEG were followed. The EEG was sampled for 5 min for each subject according to a fixed schedule. The subjects had their eyes closed during sampling, and they sat resting, leaning forward.

The EEG was stored on a DEC-PDP-11/34 and an analogue tape recorder (Tandberg, Series 100) during the experiment. Data were then FFT computer analyzed in 2-s epochs calculating the average power spectrum of each 5-min EEG sample (FFT-EEG). Each epoch was inspected for noise. Samples that held more than 30% of the total power in the 0.5–1-Hz band and more than 30% in the 18–30-Hz band were excluded. The files were copied on DEC VAX-11/750, and the power spectra were plotted on a digital plotter (Hewlett-Packard 9872A).

Tremor. Tremor in the hands was recorded with the Static Steadiness Test from the Kløve/Matthews Steadiness Battery (Lafayette Instrument Co.4605C). The subject was required to insert a stylus into two holes with varying diameters (5 and 4 mm) for 30 s and was not allowed to brace or rest his arm. The test equipment was connected to a data accumulation unit outside the chamber. Total time of contact and number of contacts were recorded for each trial.

Micro tremor. Micro tremor in the dominant hand was recorded with a Nihon Koden accelerometer (model MT-3T). The vibration pickup is designed to detect the minute, invisible vibration of amplitude 1–10 μm on the body surface, termed minor tremor or microvibration. The subject stood for 30 s with his dominant hand in a straight horizontal position with the pickup fastened to his index finger. The signal was amplified and stored on an analogue tape recorder (Tandberg, Series 100). The signals were digitized by a computer (DEC PDP-11/34) with AD converter, and stored on disk. Data were then FFT computer analyzed after the same procedure as described for the FFT-EEG. The amplitude and the frequency spectrum of the tremor were then plotted.

Finger oscillation speed. The Finger Tapping Test from the Halstead/Reitan Test battery was used. The subject was given 5 trials, each lasting for 10 s, using the index finger on the dominant hand.

Hand grip strength. Hand grip strength was measured in kilograms with a dynamometer (Lafayette Instrument Co. 78010).

Visuomotor speed. Visuomotor speed and coordination were tested with the Trail Making Test. This is a paper-and-pencil test in which the subject is asked to draw a line between circles containing letters and numbers. The subject is instructed to alternate between increasing numbers and the letters of the alphabet.

Cognitive tests

Long-term memory. The subjects were given 30 s to memorize a list of 10 pairs of words (where: bay, depth: 50 msw., etc.). Fifteen minutes later the first word of each pair was presented and memory for the paired word tested.

Reasoning. The subjects were presented with sheets of verbal assertions for 1 min (example "BA-A precedes B") (16). Half of the assertions were correct and half false and all were randomized. The subjects were required to rate the statements as true or false.

Arithmetic. The subjects were presented with sheets of mathematical statements (additions) for 1 min. Half of the statements were wrong and half correct, randomized order. The subjects were required to rate the statements as true or false.

Perceptual speed. Forty pairs of numbers with 5–10 digits were presented on a sheet. The subjects were given 1 min to compare the numbers and mark pairs with different numbers with "−" and with equal numbers with "+."

Diver symptoms questionnaire

Checklist questionnaires regarding symptoms of HPNS were presented. In addition, the subjects filled out a questionnaire for mood, body feelings, and sleep quality. They were allowed to add comments not specified on the questionnaire. Each item should be graded on a 5-point scale (1:none, 2:some, 3:some, with optional impact, 4:much, and 5:severe).

RESULTS

Test-by-test analysis

Electroencephalography (FFT-EEG). Twelve of the 18 divers showed minor changes in their FFT-EEG during the compression compared to their predive average. An example is presented in Fig. 1. At surface, the relative alpha-band power was 64 and 63%, respectively, for the left and right hemispheres (1 SD = 7 and 10%, respectively). Except for a 14% reduction in alpha-band power at 80 msw, this activity was relatively stable throughout the compression to 360 msw (Table 2). Compared with the predive

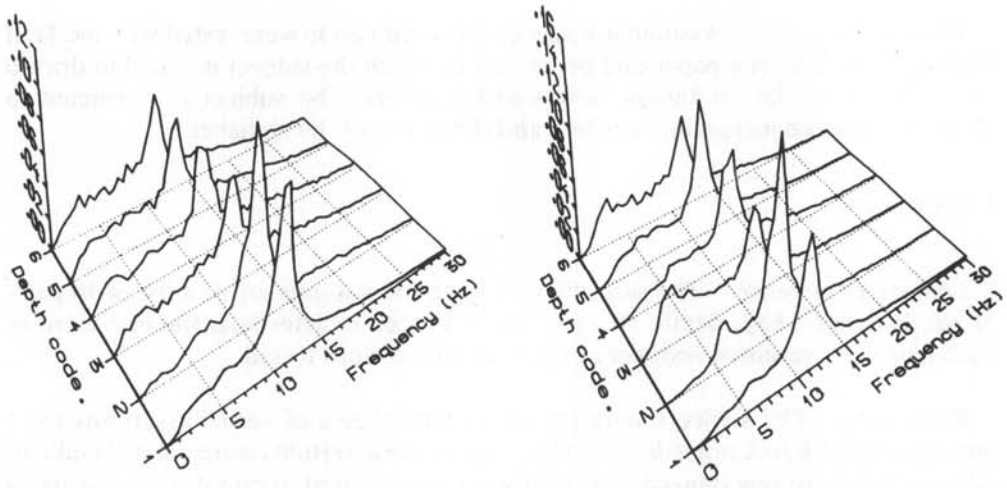

Fig. 1. FFT–EEG for 1 diver left and right hemisphere, respectively, during the compression to 360 msw (1: predive average, 2: 80 msw, 3: 160 msw, 4: 240 msw, 5: 320 msw, and 6: 360 msw).

alpha-band activity there was a significant decrease at depth. This was most pronounced on reaching 240 msw ($t = 5.34$, $P < 0.001$) and on reaching 360 msw ($t = 5.17$, $P < 0.001$).

For theta-band activity, a small but significant increase had already occurred at 160 msw ($t = 3.43$, $P < 0.003$). For alpha-band activity, no further changes occurred related to depth, but again a wider range indicated more individual variation at depth (Table 2). The theta-band change was significant compared with predive levels for all test trials throughout the compression from 160 msw.

Relative power of delta-band activity at surface had an average of 6 and 7% for the left and right hemispheres, respectively (1 SD = 3% for both hemispheres). As for the alpha band activity, the major change in delta occurred at 80 msw with an increase to 12 and 15% for the two hemispheres ($t = 3.06$, $P < 0.007$) (Table 2). No further increase in delta-band activity occurred during the compression to 360 msw.

Micro tremor. The Fourier analysis showed no changes in the center frequency of the micro tremor, which predive was around 8–12 Hz for all divers. There was, however, a wide individual variation in tremor increase on reaching 360 msw from an average of 8.1 mV (1 SD = 4.2) at surface to 32.7 mV (1 SD = 25.8). The increase in amplitude was significant on reaching 320 msw ($t = 2.63$, $P < 0.05$).

Static steadiness. Given the small average increase in micro tremor, there were also small effects observed on the Static Steadiness Test. The major changes were found on reaching 240 and 360 msw with an average increase of about 2 SD from predive level (Fig. 2) ($t = 2.89$, $P < 0.01$).

TABLE 2

AVERAGE RELATIVE POWER OF DELTA, THETA, AND ALPHA ACTIVITY FOR LEFT AND RIGHT HEMISPHERE, RESPECTIVELY, PREDIVE AND DURING THE COMPRESSION TO 360 MSW. NUMBERS IN PARENTHESIS ARE 1 SD OF THE AVERAGE RESULT

		Predive Average	1 SD	80 msw	160 msw	Reach 240 msw	Leave 240 msw	Reach 320 msw	Leave 320 msw	Reach 360 msw
Delta	Right	7	3	15 (9)	14 (8)	11 (7)	11 (6)	13 (12)	12 (8)	16 (9)
	Left	6	3	12 (8)	16 (10)	14 (9)	12 (7)	11 (6)	11 (6)	15 (9)
Theta	Right	14	4	18 (7)	19 (8)	19 (7)	21 (9)	18 (10)	19 (6)	21 (8)
	Left	13	4	15 (7)	21 (9)	20 (8)	21 (10)	17 (7)	18 (7)	21 (8)
Alpha	Right	64	7	50 (19)	49 (16)	56 (16)	54 (16)	55 (21)	56 (18)	50 (18)
	Left	63	10	54 (19)	48 (18)	49 (17)	54 (15)	53 (17)	55 (17)	48 (16)

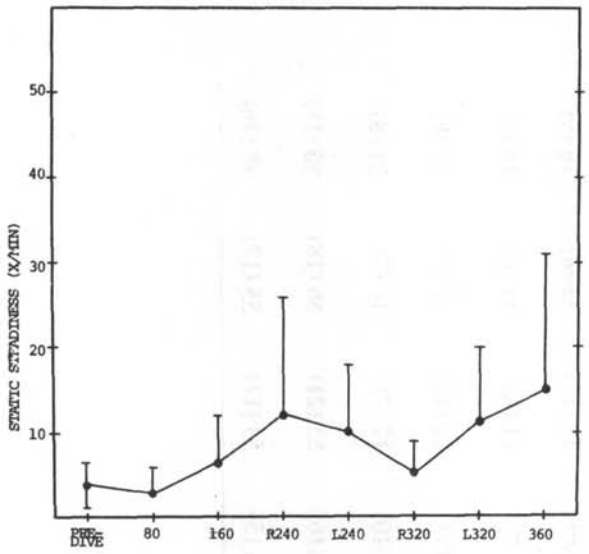

Fig. 2. Average results and 1 SD on the Static Steadiness Test (times/min) during the compression to 360 msw.

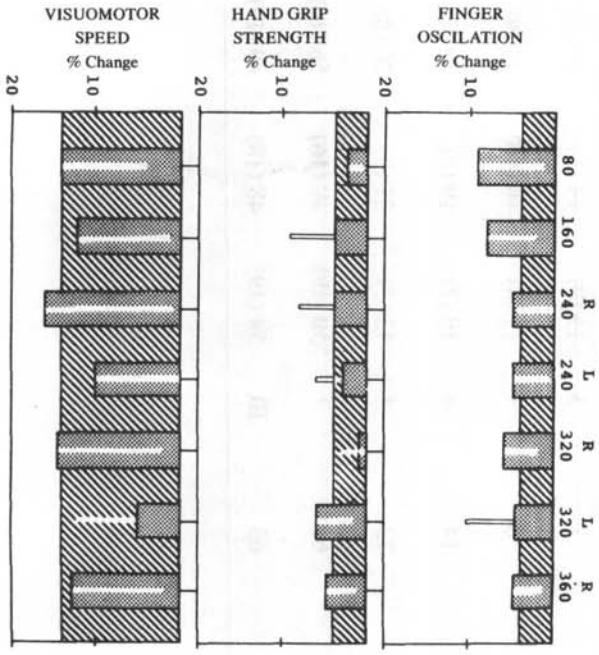

Fig. 3. Average results and 1 SD on the Finger Oscillation Test, hand grip strength, and visuomotor speed during the compression to 360 msw. Average results are calculated in percent change from the predive average, which here is defined as 100%. *Cross-hatched* area is 1 SD of predive average. *R* = reach, *L* = leave.

Finger oscillation. Possibly due to finger arthralgia, an 8–9% impairment in finger oscillation had occurred already at 80 and 160 msw (Fig. 3). During the rest of compression there was an average impairment of about 1 SD from predive control levels.

Hand grip strength. During the compression to 320 msw the average impairment was within the normal range of variation. On dive Day 2 on leaving 320 msw and on reaching 360 msw, some minor impairments were observed (Fig. 3).

Visuomotor speed. During the compression to 360 msw, the average impairment was mainly within the normal range of variation (Fig. 3).

Long-term memory. As indicated by the standard deviation, this memory test is very variable with regard to day-to-day performance. Except for an impairment of about 1.5 SD at 160 msw, the average scores were within the normal range of variation (Fig. 4).

Arithmetic. The average results were within the normal range of variation on this test throughout the compression (Fig. 4).

Reasoning. The average results were within the normal range of variation on this test throughout the compression (Fig. 4).

Perceptual speed. Except for an isolated finding at 240 msw, the average results were within the normal range of variation throughout the compression (Fig. 4).

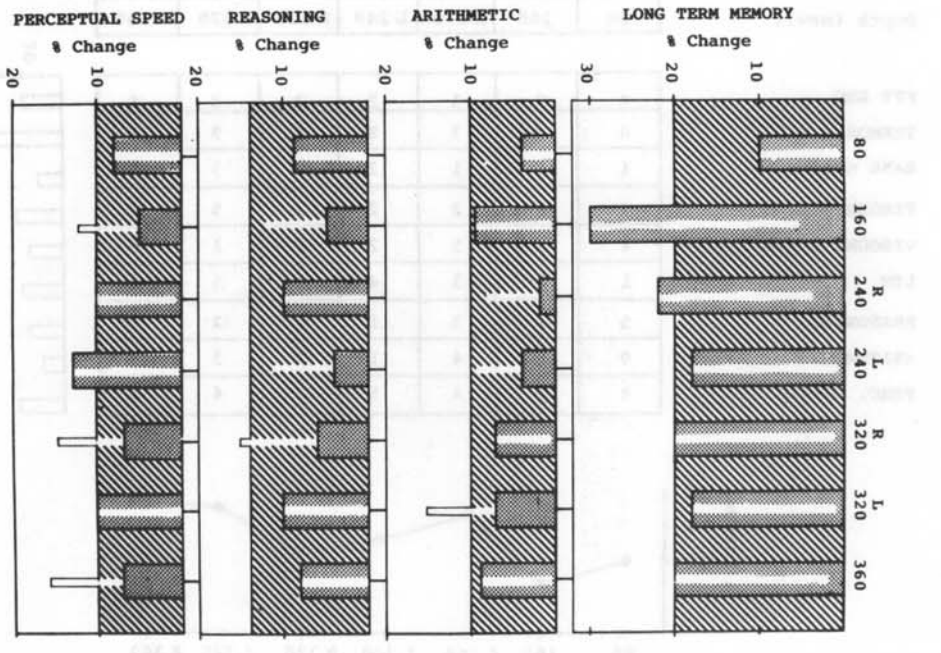

Fig. 4. Average results and 1 SD on long-term memory, arithmetic, reasoning, and perceptual speed during the compression to 360 msw. Average results are calculated in percent change from the predive average, which here is defined as 100%. *Cross-hatched* area is 1 SD of predive average. *R* = reach, *L* = leave.

Overall test analysis

The overall trends of tests and depth are described in Fig. 5, where number of subjects with impairment of 2 SD or more are plotted. The most marked changes were seen with tremor followed by impairment in finger oscillation and perceptual speed. The least affected functions were hand grip strength and sustained attention (arithmetic). This is shown at the upper right of the figure.

In general, the CNS was most affected on reaching (R) 240 msw followed by a recovery at stable depth and on reaching 320 msw (Fig. 5, *bottom*). There was again a worsening in CNS function on dive Day 2 before leaving (L) 320 msw and on reaching 360 msw. There was no statistical interaction over tests and depth. The only tendencies found were that the tremor increase occurred at 240 msw and was sustained going deeper, and second, that finger oscillation impairments were most pronounced at the beginning and at the end of compression. There were no correlations between the neurophysiologic, neuropsychologic, and performance tests.

Diver status

The majority of symptoms reported throughout the compression were only graded as 2 (''some''). The *asterisk* in Table 3 indicates single subjects who rated the particular symptom as 3 (''some, with operational impact''). The four most frequent repeated symptoms were ''unusual tiredness'' (25 times), ''arthralgia'' (33 times), ''dizziness'' (23 times), and ''felt cold'' (23 times).

Depth (msw):	80	160	R 240	L 240	R 320	L 320	R 360
FFT EEG	0	2	3	2	2	3	6
TREMOR	0	4	7	8	6	9	8
HAND GRIP	1	1	1	2	2	3	3
FINGER OSC.	6	3	2	2	3	5	4
VISOUM. SPEED	4	0	5	2	1	1	4
LTM	1	2	3	4	3	5	2
REASONING	5	1	3	1	2	2	4
ARITHMETIC	0	0	4	1	2	3	3
PERC. SPEED	4	2	4	5	2	4	3

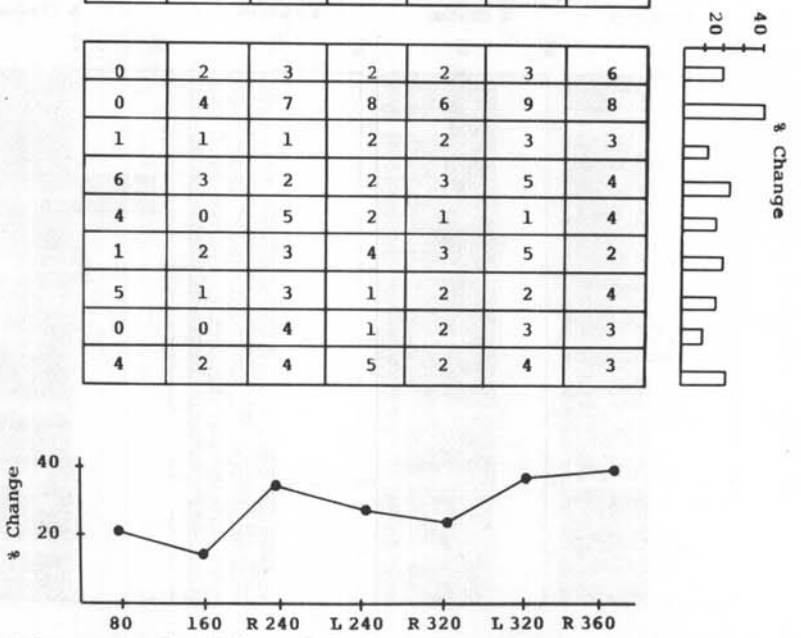

Fig. 5. Condensed data presentation of all tests indicating number of divers with an impairment of 2 SD or more. *Lower curve* indicates the general level of test impairment at the different depths. Curve at *right* indicates the relative impairment on the different tests during the compression. *R* = reach, *L* = leave.

TABLE 3

SUBJECTIVE SYMPTOMS DURING THE COMPRESSION TO 360 MSW. ALL WERE RATED AS "SOME." ASTERISK, INDICATES SINGLE SUBJECTS WHO RATED THE SYMPTOM AS "SOME, WITH OPERATIONAL IMPACT."

	Compression						
	R 80	R 160	R 240	L 240	R 320	L 320	R 360
Concentr. diff.			4	1	3	2	2
Nasal discharge		1					
Poor appetite			1*			4	2
Dizziness		4	7	3	3	2	4
Unusual tired	2	3*	7	4	4*	10*	5
Nausea						2	1
Coughing spell			1	3	2	1	2
Breathlessness						1	
Lethargic			3	1		3	
Visual distrub		1	3	2	2	2	1
Upset stomach				1	1	3	2
Sweatiness	1		1	1	1	1	3
Unusually depressed			1				
Tremors		2	2*	3	2	2	8
Clumsy	1		1			1	1*
Headache							1
Cramps-jerks						1	1
Arthralgia	1	5	7	5	5*	6	4*
Muscle aches		1	1	1	1	1	1
Light headed				1	1		1
Pain shoulder		2	1*	4	4	4	4
Pain elbow			1	1	2	1	
Pain fingers				1	1	1	1
Pain hip			3	3	3	2	2
Pain knee-ankle		1	2	3	3	3	3
Pain groin						1	1
Pain wrist		1	3	4	5	4	2
Euphoria	1	3	2	2	1	2	1
Felt hot	3*		3		*	2	2
Felt cold	4	6*	3*	2	3	2	3
Loose stools			1				
Reduced sex interest				1		1	
Vomiting			1				

* = 1 × 3. R = reach; L = leave.

As for the CNS tests, reaching 240 msw led to a higher frequency of symptoms followed by a decrease in symptomatology at stable depth and on reaching 320 msw, on dive Day 2. However, there was a high frequency of symptoms both before leaving

320 msw and on reaching 360 msw. As for the CNS test, there were no statistical interaction effects between symptoms and depth.

DISCUSSION

The HPNS testing during this dive series revealed only very mild effects from the compression. Most of the findings were scattered and did not approach levels of significant abnormality compared to previously monitored HPNS effects during compression to deep depths (12, 13). Twelve of the 18 divers had minor changes in their FFT-EEG during compression, compared to their predive average. The Fourier analysis of the tremor revealed no changes in center frequency, but a wide individual variation was observed regarding amplitude increase. The tremor results for the Static Steadiness Test showed that the major changes occurred on reaching 240 and 360 msw, with normalization at stable depth.

The motor performance tests, finger oscillation and hand grip strength, showed a stable impairment of about 1 SD in finger oscillation, possibly due to the mild compression arthralgia reported. Eye-hand coordination was, however, normal for the Trails test. The cognitive performance tests revealed an average memory score within the normal range of variation, except at 160 msw. Average scores on reasoning and sustained attention were also within the normal range of variation throughout the compression.

The majority of symptoms reported throughout the compression were only graded as 2 (''some'') with tiredness, arthralgia, and dizziness being the most frequent. As found in previous studies, there were no correlations between symptomatology and changes on the HPNS test battery.

Individual variation was a striking feature of the results, with the divers often showing very different patterns of abnormal test results. This confirms previous studies reviewed by Bennett (17). This lack of a clear pattern in symptoms of HPNS, when the symptoms are mild, is a strong argument against pressure-related symptoms being considered to be a single and uniform syndrome. Symptoms are much more likely to be a result of many different CNS effects, rather than a single abnormality. These changes would then be further affected by the usual individual variability in neurophysiologic testing.

This variability of symptom-and-sign presentation has been noted before (12, 13) and is the basis for using multiple tests and performance for HPNS to evaluate the total effect of the compression profile. Even with more severe symptoms of HPNS, a marked variability has been noted in symptom pattern and variation in symptoms between divers.

The compression profile passes the criterion set for operational acceptability. This study has shown that it is possible to develop a heliox compression profile that makes it possible for the diver to start a bell-run on the same day as reaching bottom. Use of nitrogen in a trimix breathing gas is therefore not necessary. Previous studies, especially in animals, have shown that HPNS can be counteracted by addition of a mild narcotic agent, such as an increased partial pressure of nitrogen (18–20). Previous studies at NUTEC have, however, shown that nitrogen narcosis can be a problem (13, 21). Having a gas change from trimix to heliox before decompressing can also be a danger since a previous study has shown that marked abstinence reaction from

nitrogen saturation can occur, such as myclonic jerks and hallucinations (17). Later studies (22) have, however, shown that lower percentages (5 and 6%) of nitrogen will give no narcosis and still inhibit HPNS.

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Værnes RJ, Bergan T, Warncke M. Effets du SNHP chez 18 plongeurs lors d'une compression à l'héliox à 360 mes. Undersea Biomed Res 1988; 15(4)241–255.—La compression avec de l'héliox à une profondeur supérieure à 16 ATA peut induire des changements dans l'électroencéphalogramme (EEG) associés avec une confusion et de la somnolence. Chez l'homme, les symptomes reliés au syndrome nerveux de la haute pression (SNHP) peuvent aussi inclure une augmentation du tremblement, des troubles de mémoire, de l'étourdissement, de la nausée et du vomissement. Un profile de compression développé pour l'utilisation opérationelle jusqu'à 360 mes fut évalué dans une série de 3 plongées à NUTEC. Dans chaque plongée, 6 plongeurs différents furent comprimés à 360 mes avec de l'héliox. Des tests neuropsychologiques et neurophysiologiques furent effectués itérativement. Les tests de SNHP ne révélèrent que des effets modérés de la compression. Seulement 3 plongeurs manifestèrent des détériorations de plus de 2 DS de la fonction motrice périphérique comparativement à leur moyenne témoin d'avant plongée. La mémoire fut affectée périodiquement chez 2 plongeurs. Le même effet fut trouvé dans la vitesse de perception et le raisonnement. Cinquante pourcent des plongeurs avaient une augmentation de plus de 2 DS dans le tremblement postural, mais ceci n'affecta pas leur performance motrice. Six des 18 plongeurs avaient un spectre de puissance de l'EEG avec un inhibition de la bande alpha et une augmentation de la bande theta. Tandis que la détérioration de la performance était plus marquée autour de 240 mes, les changements de l'EEG survinrent surtout au-delà de 300 mes. Des changements marqués de l'EEG, une augmentation importante du tremblement et une détérioration significative de la performance cognitive furent notés simultanément chez seulement 1 des 18 plongeurs. Même si des signes de SNHP furent observés, les plongeurs étaient peu affectés durant la compression à 360 mes. Les résultats confirment que l'emploi d'un profile de compression, avec des vitesses décroissant progressivement avec l'augmentation de la profondeur et plusieurs paliers intermédiaires, assure des plongeurs en bonne forme une fois rendu au fond. L'utilisation de batteries de tests standards du SNHP rendit possible l'obtention d'évidences pour l'acceptation de ce profile de compression.

Værnes RJ, Bergan T, Warncke M. Efectos del SNAP en 18 buceadores durante la compresion a 360 mas con heliox. Undersea Biomed Res 1988; 15(4):241–255.—La compresion con heliox mayor de 16 ATA puede ocasionar cambios en el EEG asociados a confusion y somnolencia. En el hombre, los sintomas que se denominan Sindrome Neurologico de Altas Presiones (SNAP), puede incluir tambien temblor pronunciado, alteraciones de la memoria, mareo, nausea y vomito. En el NUTEC, en una serie de tres inmersiones, se evaluo el perfil de compresion desarrollado para operaciones a 360 metros de agua salada (mas). En todas las inmersiones se comprimio a seis buceadores diferentes a 360 mas con heliox. Se realizaron pruebas neurosicologicas y neurofisiologicas repetidas. Las pruebas para SNAP revelaron solo efectos leves durante la compresion. En solo 3 buceadores se encontro deterioro en mas de 2 SD en la funcion motora periferica, al realizar la comparacion con su promedio previo a la inmersion. La memoria se afecto periodicamente en 2 buceadores. Lo mismo ocurrio en la velocidad de percepcion y de razonamiento. Cincuenta porciento de los buceadores presentaron un aumento de mas de 2 SD en el temblor postural, sin embargo, los efectos sobre la funcion motora fueron minimos. Seis de los 18 buceadores presentaron un trazo EEG con inhibicion de ondas alfa y aumento de theta. Mientras que el deterioro de la funcion es mas marcado a 240 mas, los cambios en el EEG ocurrieron principalmente a mas de 300 mas. En solo 1 de los 18 buceadores se presentaron cambios pronunciados en el EEG, aumento notable del temblor y deterioro importante de la funcion cognocitiva, al mismo tiempo. A pesar de que se observo SNAP leve, los buceadores sufrieron poco deterioro durante la compresion a 360 mas. Los resultados confirman que con el empleo de un perfil de compresion en el que se

disminuye progresivamente la velocidad, al aumentar la profundidad, y con varias paradas intermedias, se puede contar con buceadores aptos a esa profundidad. Se pudo obtener evidencia para la aceptacion de este perfil de compresion, empleando la bateria de pruebas estandar para SNAP.

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