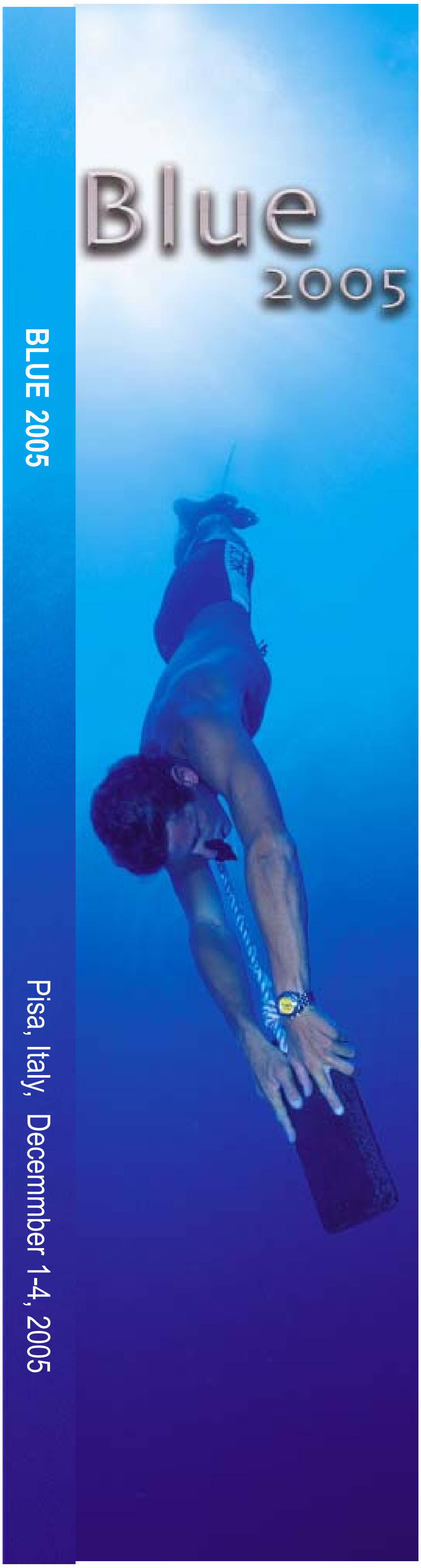

human Behaviour and Limits in Underwater Environment

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CNR Institute of Clinical Physiology, Pisa - Italy
Apnea Academy - Italy
University of Chieti - Italy

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In Memory of Prof. Pier Giorgio Data

The President of BLUE2005
human Behaviour and Limits in Underwater Environment;
special conference on breath hold diving
Pisa, Italy - December 1-4, 2005

A remembrance of Pier Giorgio Data just few days after he passed away, is a difficult and very complex task: only time, but even more so, evoking him over time with the necessary quietness and attention, will help us to better refine his scientific connotation and the rare human features that characterised his life.

Today, in occasion of the Conference and of the forthcoming speciality Master in Underwater & Hyperbaric Medicine entitled to his name, we can only evaluate and bear the "weight" of his absence.

A hard worker, as much solitary as tireless, he always engaged enthusiastically in basic research as well as in the related academic aspects, displaying to his co-operators his quaint disposition, sometimes difficult, but always open and ready for passionate discussion and for a deeper insight.

Together with few other scientists - Odaglia, Marcante, Ficini - Pier Giorgio Data represents a milestone of the Italian Hyperbaric and Underwater Medicine, a matter that, thanks to these foregoers, was turned from the empiric and pioneering early state to a true new scientific discipline.

The School in Chieti, which he strongly wanted and sustained with genuine effort despite many obstacles encountered over the years, educated many Specialists for decades, Medical Doctors who have carried his fruitful teachings to many hyperbaric Centres across Italy.

A dutiful acknowledgment of his work, a deep thanks to his constant figure of Master, be the pillars of the present Conference which is starting permeated by his Memory

Ricordare Pier Giorgio Data a così breve distanza dalla sua scomparsa, risulta impegno quanto mai difficile e complesso: il tempo, e più ancora ripensarlo nel tempo con pacata attenzione, serviranno meglio a definirne l'ampia connotazione scientifica e la singolare caratura umana che in vita lo hanno contraddistinto.

Oggi, in occasione di un Congresso e nell'imminente inizio di un Master specialistico a lui dedicati, possiamo soltanto valutare e sopportare il peso della *sua assenza.*

Grande lavoratore, tanto solitario quanto instancabile, sempre entusiasticamente impegnato sia nella pura ricerca che nella sua estensione didattica, rivelava ai suoi collaboratori un carattere estroso, difficile a volte, ma sempre aperto e pronto alla discussione appassionata, al confronto più approfondito.

Insieme a pochi altri nomi - Odaglia, Marcante, Ficini - Pier Giorgio Data rappresenta una pietra miliare della Medicina iperbarica e subacquea italiana, trasformata, per loro merito, da empirica e pionieristica pratica iniziale a rigorosa e nuova disciplina scientifica.

Alla scuola di Chieti, da lui voluta, fondata e sostenuta con generoso impegno nonostante molteplici avversità, si sono formati per decenni Medici specialistici che oggi, in Centri iperbarici disseminati in tutta Italia, ne attuano proficuamente gli insegnamenti.

Un doveroso riconoscimento della sua opera, un profondo ringraziamento alla sua costante figura di Maestro, siano alla base del Convegno che, permeato dalla sua memoria, sta per svolgersi.

Acknowledgements

The organisers wish to thank the colleagues of the "Apnea Academy School for Instruction and Research in free diving" , the Technoscience Unit of the Institute of Clinical Physiology of the Italian National Research Council in Pisa (IFC CNR) and the Colleagues of the Post-doctorate school for the Medicine of Swimming and underwater activities of the University of Chieti for their contribution to the technical-scientific organisation of the event.
Special thanks go to Prof. Luigi Donato, Director of the Institute of Clinical Physiology of the Italian National Research Council and of the CNR Research Area in Pisa, that hosted the Conference; Prof. Antonio L'Abbate, scientific director of IFC and director of the post-doctorate Master in Underwater and Hyperbaric Medicine of the Scuola Superiore Sant'Anna of Pisa, Italy, for his cultural support and encouragement; Dr. Antonio Benassi, head of the Technosciences Unit of IFC, who, besides his scientific contribution, supported the Organization Committee in the conference management; Dr. Andrea Belardinelli, Researcher of IFC and Dr. Danilo Cialoni of Apnea Academy Scoientific Group for their managerial and scientific assistance; Mr. Mirko Passera, Mr. Luca Serasini and Dr. Lorenzo Guerriero for the multimedia assistance given; Mr. Salvatore La Polla, head of the Mechanographic Centre of the Research Area, for the mastery he devoted to all the typographical productions; Mrs. Manuella Walker for her thorough editorial assistance.
Last but not least, a special acknowledgment is due to Mrs. Irene Marinaro and Mrs. Daniela Grossi for their invaluable hard work in the organisation of the congress.

Ferruccio Chiesa
Nicola Sponsiello
Remo Bedini

Aims

The variety of underwater activities and the number of people practising them has greatly increased over the past decade. The appeal of marine tourism has also attracted many people with inadequate training and others with hidden pre-clinical disorders; in Europe, in 2003 alone, over 4 million people practiced underwater activities.
This growing phenomenon has uncovered a series of new medical and social implications. Yet, these issues are not reflected in literature where most reports on underwater medical investigations concern diving performances of few qualified professionals. This lack of information on a widespread sample urges us to approach the matter in a totally new way by making systematic quantitative measurements, analysing large significant samples of well selected and studied divers, and operating in reproducible conditions in a real marine environment.
Nowadays, scientific investigations on the patho-physiological, clinical and sporting aspects of underwater medicine largely involve interdisciplinary competencies. In this respect, biotelemetry technology and methodologies up today developed both for human and wildlife investigation, together with mathematical modelling, biomedical instrumentation, advanced biomedical knowledge and ICT infrastructure constitute a well established background for the "All Where" monitoring and, in particular, for quantitative underwater biomedical investigations.
In this respect, the CNR Institute of Clinical Physiology in Pisa, the School of Underwater Medicine of the University of Chieti, and the Scientific Committee of the Apnea Academy, which have engaged together in this multidisciplinary approach for underwater medicine research, organising BLUE 2005. The Conference will cover all medical and biomedical aspects of underwater medicine together with all the basic bioengineering issues required for developing models, performing quantitative analyses, and evidencing the potential exploitation of these findings into the clinical practice. Special attention will be devoted to the physiological and possible pathological modifications in th human body related to breath hold diving, nowadays one of the most growing ways to live sea for recreational purpose.

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Conference Programme

BLUE 2005 SCIENTIFIC PROGRAMME

December 1th 2005

13.00	***REGISTRATION***		
14.00	***Welcome Cocktail***		
14.45	***Opening Session*** ***Chairmen: F. Chiesa, N. Sponsiello, R. Bedini***		
15.00	**P. Bennett** **Master Lecture**	**Some Risks in Breaking Barriers to Record Depths**	
	Scuba diving Aspects ***Chairmen: S.Lahiri & P. Longobardi***		
15.30	A. Marroni et. al.	The introduction of a Deep Stop during the ascent from 25 meter No-Decompression Compressed Air Dives reduces Doppler detectable venous gas bubbles and fast tissue gas	
15.50	G. Valente et al.	Cardiovascular Adaptation to Simulated Dive at 3.7 ATA	
16.10	**S.R.Thom** **Key-note Speaker**	**Prophylactic use of hyperbaric oxygen (HBO2) in provocative diving? The mechanism for HBO2-mediated inhibition of neutrophil adhesion**	
16.40	***Coffee break & Poster Exhibition***		
17.00	G. Catapano et al.	The effect of air divings on platelet and endothelium activation: the role of the microbubbles"	***Breath hold competitions: rules and safety regulations***
17.20	S. Simonazzi et al.	Pulmonary barotrauma prevention in hyperbaric workers: a case report	
17.40	M. Brauzzi et al.	Guidelines on the treatment of decompression illness	
18.00	G. De Jaco et al.	Patent foramen ovale (PFO) may be concomitant cause of Decompression Sickness (DCS) after SCUBA diving.	
18.20	G. Calcagnini et al.	Cardiovascular monitoring during long-term diving: the "Abissi" experience	
18.40	**P. Longobardi** **Key-note Speaker**	**Breathhold diving accidents management**	
19.00	***END***		

December 2nd 2005		
9.00	**P. Lindholm Key-note Speaker**	**Glossopharyngeal breathing in Breath-Hold Diving**
	Physiology Aspects in Breath-hold Diving Chairmen: S. R. Thom & A. L'Abbate	
9.50	F. Lemaître	Effects of repeated apnoeas on diving responsein trained divers and non-divers
10.10	C. Marabotti et al.	Echocardiographic changes during breath-hold diving
10.30	E. Schagatay et al.	Increase in hematocrit after short and long term apnea training
10.50	***Coffee break & Poster Exhibition***	
	Bio-Engineering Aspects in Breath-hold Diving Chairmen: C. Balestra & E. Ferdeghini	
11.20	R. Bedini et al.	Technologies for Underwater Biotelemetry during diving
11.40	J.R. Fitz-Clarke	Computer Simulation of Deep Human Breath-Hold Diving
12.00	G.F. Ferrari et al.	The use of digital computer models of the circulation to simulate the effects of breath hold diving on hemodynamics: definition of the circulatory model and first results
12.20	G. Minak	Experimental and analitical study on free diving monofins
12.40	**Poster Discussion**	
13.00	***LUNCH & Poster Exhibition***	
14.30	**S. Lahiri Key-note Speaker**	**Breath-holding breaking point - the mechanism of its pathways**
	Methabolic Aspects in Breath-holdDiving Chairmen: L. Ferretti & R. Prediletto	
15.00	D. Galbiati	Modifications of water corporea during apneas in subjects normo-hydratated (BIA)
15.20	P. Lindholm	Breath-hold diving on an empty stomach is dangerous.
15.40	N. Sponsiello et al.	Apnoea matabolism: modifications of blood glucose and urinary catecolamines
16.00	R. Rossi et al.	Hormonal modification and DCS in underwater Apnoea
16.20	***Coffee break & Poster Exhibition***	
17.00	**S. Lundgren Key-note Speaker**	**The physiology and patho-physiology of breath-hold diving: unique or not so unique?**
	Psychologic & Physiologic aspects in Breath-hold.Diving Chairmen: S.J. Pell & N. Sponsiello	
17.30	C. Boscia	Effects of apnea in social unease
17.50	L. Manfredini	Mental and bodly approaches to sub acqueous apnea
18.10	G. Bosco et al.	Voluntary breath-holding in the morning and in the evening
18.30	***END***	
18.30	**Post Session: Breath hold spearfishing: ethic and future**	
20.00	***END***	

December 3rd 2005		
9.00	**L. Ferretti Key-note Speaker**	**Respiratory modification in elite breath hold divers**
	Physiopathology of Breath-hold. Diving Chairmen: P. Lindholm & C. Marabotti	
9.30	F. Maggiorelli et al.	Pulmonary edema in Breath Hold divers
9.50	D. Cialoni et al.	Epydemiological investigation on hemoptysis in high depth Breath Hold divers
10.10	R. Prediletto et al.	Stress of pulmonary gas exchange in breath holding dives"
10.30	C. Passino et al.	Chemoceptive sensitivity to hypercapnia and hypoxia is markedly reduced in elite apnea divers"
10.50	***Coffee break & Poster Exhibition***	
11.20	S. Correale	The role of functional endoscopic sinus surgery (FESS) for difficult sinus equalization treatment in free-divers
11.40	Di Donato et al.	HBO therapy in sudden hearing loss due to inner ear barotrauma
12.00	P. Tagliabue et al.	Blood lactate accumulation in static and dynamic apnoeas in humans.
12.20	C. Balestra et al.	Respiratory rate can be modulated by long loop muscolar reflexes from small hand muscles
12.40	M. Maric et al.	Electromyographic evaluation of free divers wearing relaxing bite
13.00	***LUNCH & Poster Exhibition***	
14.00	S. J. Pell	"Sub Culture": Preparing a public subspace habitat performancer as an analogue to outerspace operations
14.30	**Round table with Diving Pros.**	
16.30	**Mauro Ficini Prize**	
16.45	***END***	

Posters (Discussion on Dec. 2, 12:40 and during Lunches and Coffee breaks)		
1	M. Brauzzi et al.	Cerebellar ischemia, an unusual complication of decompression illness: case report
2	F. Di Donato et al.	Contrast trans-toracal ecocardiografy (CTTE) for diagnosis of patent foramen ovale (PFO)
3	I. Peretti et al.	Health effects of exposure to marine aerosol: epidemiological survey on general population sample living in Livorno
4	C. Antonelli	Therapeutic tables in decompression illness and arterial gas embolism
5	D.Galbiati	Diabets and Breath hold Diving: management of a diabetes case type 1 during a course instructors
6	M. Maric et al.	Use of a Customised Snorkel: Clinical Considerations
7	M. Maric et al.	Hitting by a boat during freedive practice: clinic case
8	T.O. Pedja	Importance of neuropsychological model of attention in apnea mental training
9	N. D'Alessandro et al.	24H Scuba diving test: cognitive responses and psychological profile
10	M.Bonomo et al.	Tight methabolic monitoring during recreational scuba diving in type 1 diabetic patients
11	F. Faralli et al.	New approaches to the prevention of decompression ilness
12	E. Ferdeghini et al.	Feasibilty analysis of a radiological lab for underwater thorax evaluation
13	F.Tocco et al.	Cardiovascular changes to "Diving Reflex"; comparison between divers and non-divers in dynamic apnea
14	G. De Jaco et al.	Emergency treatment of diving casualities in the tirrenian coast

Thursday December 1th 2005
h. 15:00 - 15:30

Master Lecture

Peter B. Bennett

Department of Anesthesiology, Duke Medical Center,
Durham, NC, USA

Some Risks in Breaking Barriers to Record Depths

Master Lecture: **Peter Bennett**
Department of Anesthesiology, Duke Medical Center, Durham, NC, USA

Some Risks in Breaking Barriers to Record Depths

Both free divers or breathhold divers and open circuit breathing apparatus dives are
Both free divers or breathhold divers and open circuit breathing apparatus dives are
being made today to ever increasing record depths. The former has reached 171 m (561 fsw) for men (Loic Leferme) and 160 m (512 fsw) for women (Tanya Streeter). The latter has recently reached 326 m (1044 fsw) with a helium nitrogen oxygen mixture (TRIMIX) by Nome Gomes.

Both types of record breaking activity carry risks of death or injury due to the unusual physiological stresses placed on the human body. Clearly as the limits of the depth of the oceans at 32,000 fsw (10,000 m) far exceeds man's ability to reach them, except in a 1 atmosphere diving bell, the deeper the dive, the greater the risk of injury or death. Breathhold divers use various methods to give them an advantage over the limitations of the lungs to give sufficient oxygen for survival during a breathhold dive and prevent blackout on ascent.

Techniques such as 'lung packing' can reduce the residual volume of the lung from 1.79 l to 1.4 l and the vital capacity can be increased from 7.8 l to 9.7 l to give more oxygen for the ascent. But even such techniques will eventually reach a physiological limit and is the subject of current research interest. On ascent the risks of gas embolism, hypoxia, and decompression sickness (DCS) are apparent.

The current increase in deep open circuit trimix (He/N_2/O_2) record breaking dives is equally as challenging and this presentation will concentrate particularly on the risks of such deep open circuit diving. These are primarily, during compression, either nitrogen narcosis and/or oxygen toxicity if breathing air, or the High Pressure Nervous Syndrome if breathing heliox or TRIMIX. Other problems include increased risk of DCS, requiring heated suits and heated breathing gas and the need to have large volumes of gas available due to the increased consumption at such depths. At depths approaching 500 m there also will be an increased risk of dyspnea or a sense of "air hunger".

This presentation will discuss some of these limitations imposed by pressure and raised pressures of gases on the human body and point to the possible risks when these are exceeded in open circuit deep record dives.

Thursday December 1th 2005
h. 15:30 - 19:00

Scuba Diving Aspects

The introduction of a Deep Stop during the ascent from 25 meter No-Decompression Compressed Air Dives reduces Doppler detectable venous gas bubbles and fast tissue gas tensions

A. Marroni, PB. Bennett, FJ.Cronjè, R. Cali-Corleo, P. Germonprè, M. Pieri, C. Bonuccelli, C. Balestra.

DAN Europe Foundation, Research Division

Keywords: decompression, venous gas emboli, deep stops, doppler bubble detection

Notwithstanding modifications to decompression algorithms and dive computers over many years, the incidence of neurological decompression sickness (DCS) has changed very little. The efficacy of stage vs. linear decompression was demonstrated as early as 1908 by Haldane. Yet changes to decompression ratios have diminished the importance of fast tissues as the leading or critical tissues and the potential need for deep stops during decompression.

Most recreational diver no-decompression dives follow a linear rate of decompression to 5m (15 fsw) for 1-3 mins followed by ascent to the surface. We examined the effect of different ascent rates and decompression stops on the precordial Doppler Bubble Scores and computer predicted tissue gas tensions on volunteer divers. Two, consecutive, 25 m dives were performed for 25 and 20 mins respectively. The dives were separated by a 3h30 surface interval. 8 different ascent protocols were used: ascent rates of 3, 10 and 18 m/min were combined with no stops, only shallow stops (6 m), or deep and shallow stops (15 m and 6 m).

The highest precordial bubble scores were observed for no stop linear ascents compared to very low bubble scores for the 10 m/min ascent rate with both deep and shallow stops.

The introduction of a 15 m deep stop appears to significantly decrease the degree of decompression stress as observed by precordial Doppler-detectable bubbles and dive computer recorded gas tensions in the 5 and 10 minute tissues. These tissue compartments may reflect gas exchange in the spinal cord with its tissue half time of only 12.5 mins.

The authors are of the opinion that the addition of a deep stop may therefore potentially reduce the incidence of spinal cord decompression sickness for this type of recreational scuba diving.

Cardiovascular Adaptation to Simulated Dive at 3.7 ATA

G. Valente, G. Calcagnini, M. Petrocchi, C. Costanzo, S. Damiani

University of Rome, "La Sapienza" and Centro Iperbarico Romano

Keywords: heart rate variability, cardiovascular adaptation , hyperbaric chamber

Bradycardia is commonly observed in divers both at rest and during exercise, but also during dry compression, although the mechanism involved are unknown, it has been hypothesized that both an elevated partial pressure of oxygen and hyperbaria are responsible. This bradycardia may be the result of a parasympathetic vagal dominance over the sympathetic nervous system control of the heart rate (hr). the spontaneous fluctuations of the heart period (i.e. heart rate variability - hrv) reflect autonomic nervous control to the heart. Spectral analysis of hrv series provides quantitative indexes of the sympathetic and parasympathetic control to the heart. hrv spectra show three main component: high frequency component (hf), synchronous to the respiration and expression of the parasympathetic (vagal) control to the heart; a low frequency component (lf), mainly related to the baroreceptor control of the blood pressure; a very low frequency component, whose meaning is still unknown. The ratio between the lf and hf components is considered a descriptor of the autonomic balance (task force, 1996). aim of this study is to assess the cardiovascular adaptation to an hyperbaric environment simulating recreational diving, by means of heart rate and hrv analysis.

We studied 15 informed healthy male volunteers (age 28-48 years), with previous experience of recreational diving. The volunteers were compressed in a multiplace chamber at the centro iperbarico romano, with the following protocol: 5 min at 0, 5, 10, 20, 27, 20 ,10, 5, 0 m. ventilation to the chamber was provided to reduce the thermal excursion during compression and decompression.

Volunteers seated in the chamber and were instructed to breath following a sound. respiration rate was set at 12 breath/m. ecg was continuously acquired via a digital holter (cardioline, italy) housed in a sealed box.

Data were analysed off-line. QRS detection was obtained by a modified version of the algorithm of pan and tompkins.HRV series were expressed as a function of beat number (tachogram, rr). Power spectrum densities were estimated by autoregressive modelling over 250-beat-long segments, visually selected. Model orders were chosen according to anderson's whiteness test and akaike's optimal criteria. mean heart rate and lf/hf ratio were compared by wilcoxon rank test. heart rate progressively decreased during the compression phase. On average the basal HR was 78.2±10.4 bpm and reached 70.5±7.8 bpm at 27 m ($p<0.01$). The average percentage reduction, respect to basal HR, were: 3.6% at 5 m, 4.4% at 10 m, 8.1% at 20 m and 10.0% at 27 m. this reduction continued also during the first stage of decompression (68.5±7.7 bpm). The lf/hf ratio decreased during the compression stage and increased during the decompression. respect to base, the reduction at 27 m was 26.5% (0.77 vs 1.05, $p<0.01$).

Simulated dive down to 27 m induced in healthy volunteers bradycardia and increase of the parasympathetic control to the heart.

Our results are consistent with those reported by Lund at al. (Acta Physiol Scan, 1999) and Sagawa et al. (Undersea Biomed Research, 1992) who observed bradycardia associated to exposure to 2.5 and 3 ata.

The observed trends of HR and lf/hf ratio were slightly different. In fact, the HRreached its minimum during the first stage of decompression, while the lf/hf ratio decreased during compression, had its minimum at the maximum compression (27 m) and then increased again.

The cardiovascular adaptation to the hyperbaric environment may depend by different factors: HR and HRV may reflect these factors differently. HRV is mainly a descriptor of the autonomic balance, while HR is affected by other factors, such as the concentration and /or partial pressure of Oxygen.

Thursday December 1th 2005
h. 16:10 - 16:40

Keynote Speaker

Stephan R. Thom

Chief Hyperbaric Med. Env. Med.
Emergengy Medicine
University of Pennsylvania, USA

The effect of the range of oxygen partial pressures (hypoxia to hyperoxia) on neutrophil adhesion

Keynote Speaker: **Stephan.R. Thom**

University of Pennsylvania, NY, USA

The effect of the range of oxygen partial pressures (hypoxia to hyperoxia) on neutrophil adhesion

This presentation will focus on the impact oxygen has on the adherence function of circulating neutrophils, or polymorphonuclear leukocytes (PMN). PMN functions, including adherence to the vascular endothelium, are an essential part of innate host defense against invading microorganisms. A long-term reduction in PMN adherence poses the threat of infection, and excessive PMN responses can add to tissue injuries. Exposure to abnormally high and to low oxygen partial pressures perturbs PMN adherence and some of these disturbances persist for many hours after an individual returns to an environment with normal oxygen tension. While exploring the underwater environment humans are subjected to a broad range of oxygen partial pressures. Breath-hold divers experience short intervals of hypoxia while scuba divers experience mild hyperoxia. Moreover, in specific situations such as with decompression sickness, rather high oxygen partial pressures are used as a therapeutic modality. How hypoxia and hyperoxia influence PMN adherence will be reviewed in this lecture. Discussion will focus on the relative risk for changes in PMN adherence due to exposure to the oxygen partial pressures associated with breath-hold diving, scuba diving, while undergoing oxygen therapy at ambient pressure, and while receiving hyperbaric oxygen therapy.

The principal pathway by which PMN irreversibly adhere to endothelium involves cell surface adhesion molecules called b2 integrins. Results from original laboratory investigations will be outlined that show the impact of oxygen on neutrophil b2 integrin adhesion molecules. These studies span oxygen partial pressures from ~7 kPa (moderate hypoxia) to ~300 kPa (hyperbaric oxygen). Partial pressure and time of exposure influence adhesion responses. Both hypoxia and mild hyperoxia can increase PMN adherence to endothelium. The brief intervals of time that elite breath-hold divers and scuba divers are exposed to abnormal oxygen tensions have little effect on b2 integrin function. On the contrary, the time of exposure and level of hyperoxia associated with hyperbaric oxygen therapy predictably inhibits b2 integrin function. This temporary inhibitory action appears to play a role in the therapeutic effect of hyperbaric oxygen for treating decompression sickness. Discussion will include the latest information on biochemical mechanisms by which hyperoxia inhibits PMN adhesion.

The effect of air divings on platelet and endothelium activation: the role of the microbubbles

G. Catapano Minotti[1], L. Di Pace[2], G. Cellamare[2], G. Corraduzza[3], F. Mastrandrea[3]

1. Fondazione S.Raffaele Monte Tabor-Cittadella della Carità Taranto.
2. Ospedale Militare di Taranto.
3. Dipartimento di Allergologia e Immunologia SS.Annunziata Taranto.

Keywords: microbubbles, platelet, endothelium

Background

Nitrogen microbubbles activate the blood platelet and coagulation system in vitro. This activation has been suggested to play an important role in pathogenesis of prethrombotic status and thus may be responsible for decompression illness during compressed air diving.

The endothelium is a functional barrier between vessel wall and blood stream. It has a complex role in haemostasis and immunological processes so that its dysfunction could be a critical factor in the pathogenesis of decompression sickness.

Methods and Results

The aim of this study was to evaluate the prevalence and possible clinical relevance of circulating bubbles, their relationship with endothelium and platelet activation after a recreational scuba dive. Sixty healthy subjects (males, age 22-55 years), underwent a color-doppler echocardiographic study in basal condition and 30-40 min after recreational dive (-30 m 30 min). Venous blood samples were taken just before the two ultrasonic studies to measure the percentages of platelets bearing the activation marker CD 62P and bearing molecules forming receptors for von Willebrand factor (CD 42 P) using flow cytometry and specific monoclonal antibodies. We also evaluated the levels of CD 40L, Trombomodulin, adhesion molecules ICAM and VCAM and some cytokines (TNF, IL1, IL8) assumed as inflammatory markers of endothelium activation.

Circulating bubbles were detected in the right heart chambers in all divers. We also observed a marked increase in the percentage of activated platelets bearing CD 62P, a rise in circulating levels of vW factor and Trombomodulin. We noted a not statistically significant increase of TNF and IL1, but a significant increase of IL8. We did not find a correlation between bubbles and platelets activation; on the contrary we established a correlation between bubbles and vW factor, Trombomodulin and IL8.

Conclusion

These data may indicate that silent gas bubbles activate the endothelium that shows an inflammatory response without loss of homeostasis of the inflammatory system. Platelet activation cannot be excluded as an etiological factor in decompression illness (DCS), but it seems too sensitive as marker to predict DCS. The exact effect of scubadiving on the endothelium has to be further investigated.

Pulmonary barotrauma prevention in hyperbaric workers: a case report

S. Simonazzi[1], F. Cardoni[1], R. Passariello[2]

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2. Imaging Science Department, Radiology, University of Rome "La Sapienza"

Keywords: Pulmonary barotrauma, Occupational prevention, Spiral-CT application

Both "national guidelines" for the 626/94 decree accomplishment [1999] and new instructions of Occupational Medicine and Industrial Hygiene Italian Society for medical surveillance [2003] show the necessity that workers health controls must be … targeted at risk … and adhere to "justification, rationalization and optimization" principles. However it's a shareable acquisition that, in absence of disbaric accidents and/or decompression illnesses, scientific understanding on long term health effects of hyperbaric environment occupational exposure are still more limited [2]. In accordance with these doctrinal, legislative and methodological issues, therefore, a "medical surveillance integrated system" of health care workers, engaged in an hyperbaric therapy unit, was set up and applied in an Occupational Medicine and Medical Radioprotection Service of an university hospital. This choice was agreed with the Management in order to define an operational approach that proves efficient in preventive terms and without to incur, at the same time, in an expenditure of resources or in an health surveillance excess. In this context and in the definition of integrative controls, a particular attention on anatomic and functional assessment of the respiratory system was applied, through advanced technique of imaging, with the aim to carry out an early detection of conditions to be predispose a "pulmonary barotrauma" [1, 4, 7]. The present contribution proposes to illustrate clinical and instrumental data, and also spiral computed tomography (CT) acquired images, in a 35-years-old nurse on assignment to an "hyperbaric oxygen therapy" unit; indeed in this subject, with negative anamnesis for pre-existing lungs pathologies, CT scan identified subpleural blebs that both by respiratory functional assessment and conventional radiography were no detected. After detecting the lung bullae, during a preventive and pre-expositive control, this woman was judged "unfit" to work in hyperbaric environment and shifted in other nursing task for precautional purpose. In this case was used a "lung assessment" preventive protocol for hospital workers of an hyperbaric therapy unit, developed by Simonazzi et al. in 2001 in the context of a rational and justifiable, flexible and balanced health protection path [5]. Recently also Toklu et al. [6] and Millar [3] have raised the question of whether routine high resolution CT scanning of the chest should form a survey of the initial medical examination for occupational divers.

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Guidelines on the treatment of decompression illness

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Keywords: Decompression Illness, Hyperbaric oxygenation

Almost a century ago, Haldane began his studies on the treatment of decompression illness but the pathway isn't still completed. In the time we have used the air tables of Van der Aue, age 1945, the minimal recompression tables of Workman and Goodman, and, last but not least, the hyperoxygenated tables of the Comex company.

The development of diving technique and the fast increase of the number of divers makes actual the problem of therapeutic failure which, in some statistic reports, has a very high percentage.

The situation has been studied several times, with a very large experience sharing, mainly in the Consensus Conferences which were held in Marseille and Palm Beach in 1996, the more recent in Lille, December 2004.

Our presentation will be oriented on the basis of the conclusions of the Jury of these conferences. There is a very large consensus on the use of US Navy Oxygen (mainly TT 6), strongly supported by several authors and by the data of their experience. On the contrary, there is not the same point of view dealing with hyperoxygenated tables. In this case the number of reports in the literature is very small.

We think that one of the most important factors that can influence the successful outcome of the therapy is the delay of time from the onset of symptoms to the start of recompression. In the area of our facility this delay is minimal (not longer than 120') and the percentage of cure after the first hyperbaric treatment is very high. A real cornerstone of the adjuvant therapy is fluidotherapy which must be started, together with normobaric oxygen, as soon as possible, either intravenous or orally, as first aid. We cannot suggest what is the most effective fluid to use, and the controversy crystalloids vs. colloids is still open. No other drugs, at the moment, can be adviced for the treatment.

In the Mediterranean area, where we have a lot of hyperbaric facilities available, the in-water recompression must never be performed. Is highly more safer the referral to an hyperbaric facility of the patient.

Patent foramen ovale (PFO) may be concomitant cause of Decompression Sickness (DCS) after SCUBA diving

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Keywords:Decompression Sickness (DCS), Patent Foramen Ovale (PFO)

The insorgence of Decompression Sickness (DCS) with neurological symptoms after SCUBA diving, even when properly conducted, is an event not rare to be observed.In some cases an accurate surveying has shown the presence of an undervalued patency of foramen ovale.

In certain physiologic conditions, or as a result of a forced compensation with engagement of the diaphragm (Valsalva), asymptomatic congenital alterations of the atrial septum may determine aright - to - left shunting of blood and bubbles, with bypassing of the pulmonary filter.The authors present some cases, among others of their case studies, of DCS occurred after correctly conduced SCUBA dives, in which specific tests, such as doppler ultrasound of the carotide arteries and contrast echocardiography with Valsalva provocation have revealed the presence of patent foramen ovale.

These cases suggest that congenital malformations may be concomitant causes of DCS.Based on their preliminary experience, the authors suggest a combined approach to DCS, based on both carotid doppler ultrasound and contrast echocardiography, also when other known causes are present.

Cardiovascular monitoring during long-term diving: the "Abissi" experience

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Italian National Institute of Health, Roma, Italy

Keywords: cardiovascular system, long term monitoring, saturation dive

Introduction: recreational scuba diving induces cardiovascular adaptation such as bradycardia and peripheral vasocostriction. So far, such effects have been investigated in professional divers (saturation dive) and during simulated dive using hyperbaric chambers. In both cases, electrocardiographic recordings were done in air. Few data collected during relatively short recreational dives are also available. The technical difficulties posed by the underwater environment are the main reasons for the lack of data.

Aim: to explore technical solutions and investigate the feasibility and reliability of long term monitoring of ECG and Oxygen Saturation during long-term diving, using commercial devices.

Methods and materials: the "abissi" experience consisted in a 10-days, continuous dive at approximatively 10 meters. two volunteers completed the experience. During these 10 days the two divers were allowed to enter a pressurised chamber for physiological needs, eating, changing the suit and for medical checks. The divers were equipped with dry suits, dry gloves and face mask and were continuously attended by two assistants.

8 video cameras provided continous monitor of the diving area. The signals we selected to collect were ECG and Arterial Oxygen Saturation. The diving suits were modified to allow a watertight pass-through for the oxygen saturation sensor and the ECGwires: a backing plate of vulcanized rubber similar to the ones used for in-let and out-let valves was glued on the suit. A PVC plate with 2 pass-trough connectors was then applied. ECGrecordings were collected by using a digital holter (Prima, Cardioline, Italy); oxigen saturation was monitored using an oxygen saturation handheld monitor (Spirobank II, Mir, Italy). Both the devices were placed in waterpoof housing, realised at the mechanical lab of the dept. of Technologies and Health, in Rome. In addition, monitor of breathing pattern during the night was attempted by video recordings of bubble pattern. The holter and the oxygen saturation recorders were switched-on at the surface, put in the housing and delivered to the pressurised chamber where the divers were waiting. 4 ECGelectrodes were applyed on dry skin in a standard Holter configuration (3 leads); oxygen saturation sensor was located in the 4th finger of the non dominant hand.

Results: Holter reecordings gave ECGtraces of quality comparable to those obtainable with conventional examinations, Oxygen Saturation sensors were prone to dislocations, breathing rate during sleep. discussion. scuba diving with dry suit offers the chance to apply electrode and sensors on the dry skin and thus allows to overcome one of the major limitation for underwater biosignal acquisition. a major drawback of this solution is given by the impossibility of repositioning or adjusting the sensors after the diver has wore the suit. this turned out to be a significant cause of failure for the measure of oxygen saturation at the finger. the positioning in other body location is thus worth to be investigated. sleep monitoring using a video camera was usefull in revealing sleep apnea. the increased inspiration resistance and the "dead space" of the face mask which may lead to an increase of carbon dioxide concentration may be responsible for such apneas. a proper regulation of the face-mask, with a constant fresh air flow reduced significantly the apnoeas. the availability of ecg traces also allows analysis of heart rate variability, at least on selected epochs. the relatively slow breathing rate typical of divers makes difficult to separate sympathetic and parasympathetic contribution to the total heart rate variability.

Thursday December 1th 2005
h. 18:40 - 19:00

Keynote Speaker

Pasquale Longobardi

Chief Hyperbaric Centre
Ravenna, Italy

Breathhold diving accidents management

Keynote Speaker: **P. Longobardi**

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Piergiorgio Data Research Group

Breathhold diving accidents management

A diver who does not respect the rules of safe breath holding diving places himself in great danger to suffer from blackout and near drowning.

Blackout is the sudden loss of consciousness caused by oxygen starvation. Divers can experience two types of blackout. Shallow-water blackout occurs when divers ascending vertically in the water column undergo pressure changes. Static-apnoea refers to blackout that doesn't involve a deep dive; it's generally related to breath-hold attempts in a shallow pool. The other one is the deep water blackout.

Researching the subject of freediving blackout for web research, it's shocking to discover that most of the world's top spearfishers had experienced close calls with shallow-water blackout.Damiano Zannini, M.D. (Italy) reported that approximately 70 percent of the Italian divers who regularly compete in national and international spearfishing competitions have suffered one or more blackouts. It's interesting to note that ama divers, with their history of hundreds of years, experience a low rate of shallow-water blackout. They stick to a conservative dive profile-they limit the duration of their dives to one minute and rest between them. They also prefer to make many short dives instead of a few long ones.

These diving accidents are probably the biggest argument for diving with a buddy, who can support and assist the unconsciousness diver. Unfortunately, this is the type of emergency that can't be recovered without the assistance of a dive buddy or other surface support. When a diver blacks out, he becomes unresponsive. In cases of Shallow Water Blackout (SWB), the breath-hold diver swimming towards the surface will exhibit various symptoms that will be readily apparent to the trained eye.

The paper concerns the following main topics:

- Signs & Symptoms of Blackout: there are described typical observations for the beginning symptoms or signs that are of paramount importance for a successful rescue.
- Assisting the Unconscious Diver: procedures used on the unconscious diver are discussed
- Prehospital Medical Care indications
- Emergency Department Care indications
- Consultations: a main topic of the discussion is devoted to determine the likelihood that symptoms are diving-related and the appropriateness of treatment with HBO therapy, even in case of breath-hold diving blackout when pulmonary oedema or alveolar haemorrhage is present. Of course, other specialized interventions are also described as that concerning the barotraumas of the middle and inner ears.

Friday December 2nd 2005
h. 9:00 - 9:30

Keynote Speaker

Peter Lindholm

Department of Physiology and Pharmacology, Karolinska Institutet, Stockholm, Sweden

Glossopharyngeal breathing in breath-hold diving

Keynote Speaker: **Peter Lindholm**

Department of Physiology and Pharmacology, Karolinska Institutet, 17177 Stockholm Sweden

Glossopharyngeal breathing in breath-hold diving

Keywords: Apnea, spirometry, MRI, lungpacking

Glossopharyngeal breathing (also known as e.g. frogbreathing, lungpacking) is used by breath-hold divers competing in the sport "Apnea" to increase performance.

By using the mouth and glossopharynx the diver may increase (Glossopharyngeal Inhalation, GI), or decrease (Glossopharyngeal Exhalation, GE) the amount of air in the lungs without using the chest muscles or diaphragm. GI is also used in medical care, e.g. by patients with post-polio or tetraplegia. GI is used by Apnea competitors in the diving disciplines (e.g. Constant Weight), for distance swimming (Dynamic Apnea) and for duration (Static Apnea). They increase the amount of air in the lungs by GI, thereby increasing oxygen stores, and the amount of air available equalization when diving for depth.

GE is used at depth when the gas in the lungs is compressed by Boyle's law, the diver may pull up air from the lungs into the mouth where it can be used for equalization by a Frenzel manoeuvre.

Both GI and GE are used for dry exercises as a method for stretching the chest and diaphragm, GE is also used in empty lung diving (a stretching manoeuvre in the water) to simulate the chest squeeze normally encountered in deep sea diving.

The amount of air in the lungs may be increased by as much as 1-4 litres by GI (up to 50% of normal vital capacity) over the total lung capacity. GE may reduce the amount of air by 2-300ml below a normal residual volume.Imaging of the chest with MRI during these manoeuvres show that there is an increase in blood in the chest during GE and a reduction of blood during GI.

Healthy volunteers have been shown to be able to learn GI and increase their vital capacity by 6 weeks of training. Risks: GI will decrease arterial blood pressure if used excessively; causing loss of consciousness due to orthostatic hypotension, and fainting is not uncommon among inexperienced divers practising GI.

Although rarely reported GI may cause lung trauma (pneumothorax). GE may easily cause syncope due to hypoxia since it is a breath-hold on empty lungs, thus empty lung diving is very dangerous if practised without proper safety routines.

Glossopharyngeal breathing is a performance enhancing method for competitors in Apnea, and has been used in most of the current world-records in breath-hold diving.

Friday December 2nd 2005
h. 9:00 - 10:50

Physiologic Aspects in Breath-hold Diving

Morphological and functional adaptation of the cardiovascular system to prolonged apnea in air in healthy diving athletes: a study with cardiac magnetic resonance

A.Pingitore, G. Di Bella, M.Passera, A. Belardinelli, L. Reale, D. Cialoni[1], R.Bedini

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Keywords: Apnea, MRI

Background
A human model for studying physiologic adaptation to extreme acute hypoxemia is represented by prolonged apnea in healthy diving athletes. Cardiac magnetic resonance (CMR) is the gold standard method for assessing regional and global function and volumes of left ventricle.

Aim of the study
To assess the morphological and functional adaptation of the cardiovascular system to prolonged apnea in air in healthy volunteers diving athletes. Methods: 10 male athletes (age 30±6 years) has been studied at rest and at apnea peak with CMR. Peak apnea time depended on the apnea ability of each athlete. During experimental condition of apnea, athlete was monitored continuously with electrocardiogram, and oxygen saturation. The following were evaluated: O2 saturation (SaO2), heart rate (HR), systolic (S), diastolic (D) and mean (M) blood pressure (BP), systemic vascular resistences (SVR, dyne/sec per cm), end-diastolic (ED) and end-systolic (ES) left ventricular volumes (LVV, ml), LV ejection fraction (EF, %), LV stroke volume (SV, ml), LV systolic wall thickening (SWT), LV diastolic and systolic wall stress (DWS, SWS).

Variables	**Rest**	**Peak apnea**	**P value**
SaO2 (%)	97±0.8	82±7	**0.0001**
HR (bpm)	74±10	71±10	Ns
SBP (mmHg)	127±9	138±15	Ns
DBP (mmHg)	79±7	94±13	**0.008**
MBP (mmHg)	94±6	108±14	**0.01**
SVR (dyne/sec per cm)	2.3±0.5	2.2±1.0	Ns
EDLVV (ml)	109±32	158±25	**0.001**
ESLVV (ml)	34±12	63±14	**0.0001**
LVEF (%)	68±7	60±5	**0.008**
LVSV (ml)	74±24	94±15	**0.03**
LVDWS (Kdynes/cm2)	2.0±0.5	3.0±0.8	**0.01**
LVSWS (Kdynes/cm2)	4.2±1.0	3.7±1.1	**0.0001**
LVSWT (%)	70±26	49±27	**0.05**

Results
The resting and peak apnea values of the variables considered are shown in the table. There was a significant correlation between SaO2 and EDV (R^2 0.33, $p<0.008$) and ESV (R^2 0.46, $p<0.001$).

Conclusion
Acute hypoxemia induced in healthy volunteers diving athletes induced the following morphological and functional changes: 1) a significant increase of the LV volumes, that inversely correlated with SaO2; 2) a reduction of regional systolic function, assessed with SWT; 3) an increase of DWS and a reduction of SWS; 4) the increase of SV, probably related to Starling effect. Thus our data are consistent with the hypothesis that cardiac response to acute hypoxemia is a complex phenomenon potentially determined by multiple imputs comprehending pre-load and after-load cardiac changes, meccanoreceptor and baroreceptor response, sympatoadrenergic and/or vagal activation, metabolic changes.

Effects of repeated apnoeas on diving response in trained divers and non-divers

F. Lemaître[1], C. Tourny-Chollet [1], D. Polin [2]

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Keywords: Lactic acid, hematocrit, breath-hold, exercise, training

Background: diving response have been observed during free diving in sea mammals as in humans. it includes cardiovascular adjustments known to decrease the oxygen uptake and then to prolong the apnoea duration in divers. The aim of this study was to determine the effects of an apnoea series (A1-A5) on the diving reflex.

Materials and Methods: in ten trained underwater hockey players (UHD) and ten untrained subjects (control: CTL), five apnoeas (45s) were performed during cycling with face immersed in thermoneutral water. A two minutes period was interposed between each apnoea.

Cardio-respiratory parameters were recorded and venous blood samples were collected before and between each apnoeas, and at 0, 2, 5 and 10 minutes after the last apnoea. SaO2 and heart rate were continuously recorded during all the experiment duration.

Results and Discussion : the physiological response to apnoea diving, i.e., bradycardia and increased arterial blood pressure, were observed and remained unchanged throughout the series of apnoeas. For both UHD and CTL, the SaO2 values decreased during each apnoea but the SaO2 were lower in uhd after A2 to A5 than in CTL ($p<0.01$). Hematocrit values were higher in UHD after A3 and A5 ($p<0.05$) than in CTL. Lactate concentration was lower in UHD than in CTL at 2 and 5 minutes post apnoea.Conclusions : results show some similitude of UHD and CTL diving response during repeated apnoeas. However, UHD show a highest degree of 02-conservation, manifested as the slowest SaO2 decline and the highest hematocrit values. Moreover, a reduce post-exercise blood acidosis in UHD compared to CTL suggests a more efficient adaptation to hypoxia.

Echocardiographic changes during breath-hold diving

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Keywords: echocardiography, breath-hold diving

The study of cardiovascular changes during breath-hold diving has been hampered by the difficulty of studying subjects fully immersed in water. Most of the knowledge in this field has been obtained on head-out immersed subjects. The recent development of a submersible echocardiographic machine allowed the study of subjects during breath-hold dive at differents depths.

Ten male subjects (age range 22-47) were studied, by Doppler echocardiography, before and during breath hold diving at 3m depth; 14 male subjects (age range 28-47) were studied, with the same protocol, before and during breath-hold diving at 10m depth. The following parameters were obtained; heart rate (HR), left ventricular stroke volume (SV), cardiac output (CO), left atrial systolic dimension (LA), right ventricular and right atrial dimension (RV and RA, respectively), early (E) and late (A) transmitral peak flow velocity.

Breath hold diving at 3m depth induced a significant reduction of HR (74±10 vs 60±12 bpm $p<0.02$), SV (67±19 vs 59±10 ml, $p<0.05$), CO (5.1±1.8 vs 3.7±1.2 l/min, $p<0.02$) and LA (37±4 vs 32±4,9 mm, $p<0.01$). During breath-hold dives at 10m depth, similar (but more pronounced) changes were observed: HR (71±10 vs 57±18 bpm $p<0.02$), SV (86±22 vs 69±24 ml, $p<0.05$), CO (5.6±2.6 vs 3.7±1.0 l/min, $p<0.01$) and LA (47±4 vs 43±6 mm, $p<0.05$). During 10m depth diving, a significant increase of E was also observed (71±13 vs 87±8 cm/sec; $p<0.01$). No significant change during diving was observed (at both depths) for RA and RV.

In conclusion, breath-hold diving induces a significant decrease of cardiac output (due to a reduction of both stroke volume and heart rate). The absence of changes in right chambers dimensions seems to suggest that most of central blood shift happens during the preparation surface floating and/or during descent. The increase in early left ventricular filling velocity observed at the highest depth, may be explained by the sharp reduction of heart rate. Finally, our data seem to suggest that shallow dives are able to induce large, clearly appreciable cardiovascular changes

Increase in hematocrit after short and long term apnea training

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Keywords: Apnea, Hematocrit, Blood boosting, Training, Spleen contraction

The maximal duration of apneas in mammals depends mainly on three factors:
1) the ability to store oxygen and carbon dioxide, 2) the tolerance to asphyxia, and 3) the ability to conserve oxygen by the diving response. A series of studies were performed to investigate the possible effects of repeated apneas, or "short-term training", and long-term apnea training on these functions. We have previously shown that the human cardiovascular diving response (heart rate reduction and selective vasoconstrict-ion) prolongs apneas by conserving oxygen, i.e. by enhancing factor 3 (Schagatay and Andersson 1998, Andersson et al 2004). The diving response was found to be enhanced by daily long-term apnea training (Schagatay et al 2000) but unaffected by repeated apneas (Schagatay et al 1999). In recent studies we focused on the effects of repeated apnea (short-term training) and long-term apnea training on hemoglobin concentration (Hb). The gas storage capacity is largely determined by the Hb and an elevation would be expected to have a positive effect on apneic duration. Hurford and associates (1990) reported spleen shrinkage and Hb increases in ama-divers, but not in untrained control subjects after diving, a phenomenon previously observed in diving seals. When we studied Hb elevations after apneas in divers and non-divers, these were more pronounced in the divers, suggesting a training effect (Richardson et al 2005). In a study where 10 intact and 10 splenectomized subjects performed repeated apneas with face immersion we found that both Hb and the easy-going phase of apneic duration were prolonged in intact subjects while there were no effects in subjects without spleens, linking blood boosting by spleen contraction to a dive prolonging function during apnea (Schagatay et al 2001). Thus humans share with marine mammals the ability to empty the spleen and elevate blood Hb which has a dive prolonging effect. A different means of increasing Hb would be by long term enhancement of erythropoiesis. The possibility that apnea may affect Hb is logical, as the transient periods of hypoxia during repeated apneas resemble those during cyclic breathing at high altitudes, known to enhance erythropoietin (EPO) production by the kidneys and in turn increase Hb. When we studied Hb levels in resting elite apneists, elite skiers and untrained subjects, Hb levels were found to be highest in the divers. We then studied the effects on blood EPO levels of 15 subsequent maximal apneas in 10 subjects, and found an increase in circulating EPO by 15%, with a peak after 3 h. No changes occurred on a control day without apneas. Factor 1 could thus be affected by two different mechanisms for elevating Hb: by the blood boosting spleen contraction induced by serial apneas and by enhanced EPO and possibly a long term

elevation of erythropoiesis. What about factor 2, the tolerance to asphyxia? We compared the breaking point arterial saturation (SaO_2) levels in 5 trained apneists and 5 untrained subjects of similar ages. The protocol consisted of 3 maximal duration apneas spaced by 2 min of rest. Apneas were performed in a horizontal resting position and after normal respiration and a deep inspiration of air and no feedback on duration. The 5 apneists interrupted the apneas at a mean SaO_2 level of 76% (SD 6.6), while the untrained subjects interrupted at 92% (SD 1.4; $P<0.001$). The corresponding values for expired end-tidal O_2 were 8.1% for apneists and 12.3% for untrained ($P<0.001$) and end-tidal CO_2 values were 7.5% for apneists and 6.5% for untrained subjects ($P<0.001$). The inspired values were the same for both groups. This shows that the tolerance to hypoxia and hypercapnia is enhanced in the trained apneist. In summary we have shown that all 3 factors determining apneic duration respond to apnea training.

Friday December 2nd 2005
h. 11:20 - 12:40

Bioengineering Aspects in Breath-hold Diving

Technologies for Underwater Biotelemetry during diving

R. Bedini, L. Reale, A. Belardinelli, M. Passera, L. Guerriero, A. Navari, A.Dalle Luche, A. Benassi, E. Giuffre[1], D. Cialoni[1], A. Pingitore, C. Marabotti[2] and PG. Data[3]

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Key words: biotelemetry, underwater, monitoring

The variety of underwater activities and the number of people practising them has greatly increased over the past decade. The appeal of marine tourism has also attracted many people with inadequate training and others with hidden pre-clinical disorders; in Europe in 2004 alone, four million people practiced diving activities. This growing phenomenon has uncovered a series of new medical and social implications which are not reflected in literature, where most reports on underwater medical investigations concern diving performances of few qualified professionals. This lack of information on a widespread sample urges to approach the matter in a totally new way by registering systematic quantitative measurements on large samples of divers, and operating in reproducible conditions in a real marine environment.

The novelty of the presented approach runs along two converging directions. On one, it will design a wide range of non-existing submarine medical instrumentation, set up operative monitoring protocols that establish proper collection of biomedical data in terms of quantity and quality setting of the series of cases, possibly investigated through the developed instrumentation mentioned above. On the other it will employ new instrumentation to investigate by an unconventional methodology unexplored aspects of human cardio-vascular-respiratory physiology in a real underwater medical lab.

Systematic instrumental clinical analysis will effectively address performance-safety, translating into scientifically-based guideline regulations for underwater labour and into consolidated bases for underwater medicine.

Important technical challenges concerning the creation of new submarine instrumentation such as a two dimensional echographer, an electrocardiographer, a holter, a spirometer, etc. have been overcome; specific medical operating protocols have been also developed to assure an underwater use of the monitoring instrumentation the least invasive and stressing as possible for the diver to deal with and as familiar as possible for the physician to operate.

The aspects and the developed instrumentation described involve interdisciplinary competencies, which solicited the authors to fuse complementary knowledge from technical, medical, and diving practitioner's point of views, to effectively face the problems prompted by the emerging area of diving activities.

Computer Simulation of Deep Human Breath-Hold Diving

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Keywords:simulation, math model, apnea, breath hold, divingng

Champion free divers have reached depths over 170 metres on a single breath of air, and sustained surface breath-holds over 9 minutes.

An important enabling factor is the set of diving reflexes involving bradycardia, peripheral vasoconstriction, and splenic contraction that are enhanced by training, and likely help conserve oxygen. While heart rates and expiratory gas samples have been obtained during breath-hold dives, scientific studies have been severely limited by difficulties obtaining invasive hemodynamic measurements during deep dives. Ultimate human depth limits on a single breath remain the subject of speculation.

We developed a computer model of the lungs, chest, abdomen, and cardiovascular system to study changes in blood flow, pressures, and gas exchange during apnea, immersion, and breath-hold dives up to 200 metres depth. The model simulates lung compression, thoracic blood shifts, heart chamber distension, and pulmonary capillary stresses. changes in oxygen and carbon dioxide partial pressures are tracked beat-by-beat in lung, blood, and tissue compartments before and during dives.

Championship level static apnea, constant weight dives, and deep no-limits dives have been simulated. results will be presented including the effects of lung packing hyperinflation, exhale dives, swimming exertion, and diaphragmatic contractions.

Pulmonary capillary stresses exceed 50 mm hg on dives to 200 metres, within the range of stresses known to cause lung damage in animal experiments.

Arterial levels of oxygen remain high for several minutes during static apnea, highlighting efficient maintenance of pao2, despite extraction from the lungs.

Alveolar carbon dioxide levels are lower during deep dives, as compared with those near the surface, due to the enhanced gradient for gas transfer into blood, and delayed release during ascent.

Results of hemodynamic changes and gas exchange in the model correspond well with available experimental data.

This is the most sophisticated computer model yet applied to breath-hold diving, and serves as a useful tool to explore beat-to-beat cardiopulmonary interactions and respiratory gas exchange in a variety of practical diving scenarios.

The use of digital computer models of the circulation to simulate the effects of breath hold diving on hemodynamics: definition of the circulatory model and first results

G. Ferrari, C. De Lazzari, L. Reale, R. Bedini

CNR Institute of Clinical Physiology, Rome-Pisa, Italy

Keywords:circulatory model, lumped parameters, breath hold diving

It was shown that breath-hold diving can modify circulatory conditions. As in other cases of external actions exerted on the circulatory system, the effects of diving depend on several factors including starting circulatory conditions, age, general conditions of the subject and, of course, depth. On the other hand, circulatory parameters that can be measured under water are not many and the interpretation of acquired data is not easy both for the limited amount of acquired variables and for the number of factors that could influence hemodynamics in under-water environment.

The use of a digital computer model of the circulation could help to analyze data and predict, to some extent, the trend of other circulatory variables that cannot be easily measured in these extreme conditions.

Available data in our experimental environment are, in general, heart rate, cardiac output and ventricular volumes. On this basis, the question is how should be constructed the circulatory model and which kind of additional information could be extracted from it. Our approach to this problem was to use a simple lumped parameters circulatory model able to reproduce artero-ventricular interactions and pressure-volume distribution at the level of large vessels. This type of model can be set up using a limited amount of parameters and can give additional information about pressures and distribution of volumes inside the body. Ventricular function is reproduced by variable elastance models.

The model was developed in LabVIEW environment and is divided into six sections: left and right heart (including atria), systemic and pulmonary arterial circulation, systemic and pulmonary venous circulation. The effects of diving are reproduced polarizing systemic venous compliance that includes splanchnic circulation. Another important parameter that can be set in the model is intrathoracic pressure.

It was demonstrated that intrathoracic pressure has important effects (for example during artificial ventilation) on cardiac output. Data available in literature show that at breath-hold before diving intrathoracic pressure reaches high negative values able to produce remarkable effects on hemodynamics.

Finally, a simple algorythm based on the changes in ventricular end-diastolic volume was added to the model to control heart rate. Set up of the model was conducted in the following way: breath-hold condition at zero depth was assumed to be the control. It was assumed as well that ventricular elastance did not change during diving. Intrathoracic pressure was set at a value of -12 mmHg.

The heart rate control was set to have a heart rate corresponding to the heart rate in the starting condition (zero depth). Polarization of systemic venous compliance was changed according to the depth. First results of simulation show that at 10 meters depth heart rate and CO drop of about 22% and 28% respectively, average pulmonary arterial pressure drops of about 40% and, finally, SV decreases of about 15%.

These preliminary data follow the trend of available experimental data. However, the percentage drop of SV and CO is not the same in experimental data and in simulation. This could be explained, in our opinion, because intrathoracic pressure was kept constant during the simulation. Even a slight change of intrathoracic pressure during diving has shown to produce most remarkable effects on CO during simulation.

In conclusion, the simulation has shown that the effects of diving could be explained as the sum of different causes. Among them, one of the most important seem to be intrathoracic pressure changes. We are aware of the limitations of the model, however we think that it could be a useful tool to analyze breath-hold diving data, predict the trend of not measured variables and, finally, to make hypotheses on the variables to be investigated.

Experimental and analytical study on free diving monofins

G. Minak

DIEM Università degli Studi di Bologna, Italy

Keywords: Monofin, FRP, experimental analysis, Lighthill Model

Sport equipment performance analysis nowadays has a growing importance. In fact, many sports are extensively equipment dependent and the overall athlete's performance is widely influenced by technical features. In free diving recently new materials have been adopted for fins and monofins like glass or carbon fibre reinforced composites. The choice of the geometry, of the material and of the lamination lay-up is based on experience and the experts feeling, not on quantitative measures

A monofin was first used for a free diving record by Rossana Maiorca in 1991, but it was already commonly utilized in fin swimmig since many years. Nevertheless few people made scientific of technical studies on them and mainly from a strict biomechanic point of view (Reiman 1991). This is due to many reasons, first of all only in the last ten years it has been acknowledged the necessity of having high performance fins and monofins, manly for free diving records. In fact, constant weight record passed from 63 m of 1991(Pipin Ferreras) to 80 m of 1999 (Umberto Pelizzari) and to 103 m of 2004 (Martin Stephanek). The second reason is that monofin market is mainly artigianal and still to small to justify funding of research, while in the field of SCUBA diving the R&D follows different objectives, manly comfort and aesthetic design. The last reason is degree of complication of the problem, in fact we must deal with non linear materials, high strains and high displacements, fluid dynamics, fluid-structure interactions and biomechanics. Aim of this work is to test the applicability to monofins of an easy experimental methodology (Minak 2004) to evaluate their performances and to discuss the features of a well known analytical model suitable for a slender beam oscillating in a fluid (Lighthill 1960),(Mollendorf et al. 2003).

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Friday December 2nd 2005
h. 14:30 - 15:00

Keynoted Speaker

Sukhamay Lahiri

University of Pennsylvania Medical Center, Philadelphia, USA

Breath-holding breaking point - the mechanism of its pathways

Keynote Speaker: **Sukhamay Lahiri**

University of Pennsylvnia Medical Center, Philadelphia, USA

Breath-holding breaking point - the mechanism of its pathways

Keywords: Apnea, hypoxia, chemoreceptor drive, recptors, respiration

Breath-hold apnea is accompanied by alveolar/arterial hypoxia and hypercapnia. This leads to increasing intensity of respiratory stimulation which culminate in braking point of apnea. How the breaking point is reached is described in this presentation.

During breath-hold apneas, carbondioxide pressure increases almost linearly whereas the oxygen pressure dcreases alinearly. Carbondioxide pressure stimulates the central chemoreceptors primarily whreas the peripheral chemoreceptors are stimulated by both impending hypercapnia and hypoxia which also interact. A further interaction occurs between the central peripheral chemorceptors which drive the respiratory system and which leads to the braking point of apnea. To this drive is the negatively added drive is the stretch recptors activity from the shrinking lungs.

During added hypoxia, the pripheral chemorecptor activity increases sharply, reducing the breath holding time.

By analysing the the rising peripheral chemoreceptor activity we can establish the role of the chemorecptor drives (periphral + central) in reaching the breaking point.

There are many other lessons can be learnt about respiration from hreath-holding experiments.

Friday December 2nd 2005
h. 15:00 - 16:00

Methabolic Aspects in Breath-hold Diving

Modifications of water corporea during apneas in subjects normo-hydratated (BIA)

D. Galbiati .

Scientific Committee of Apnea Academy, Italy

Key words:water corporea, apnea, BIA

Aim

We have quantified variations of some parameters of body composition like the TBW and the ECW in 96 subjects that practiced apnoea, and that had previously achieved a licence of the didactics Apnea Academy (A.A.); the subjects have been estimated before and after seated of apnoeas in static phase, dynamics phase, constant order and variable order. The subjects were all in state of normal hydration. The objective has been also to draw practical indications on the regarding nutrional aspects of hydration in still little known sport like apnoea.

Material and method

Not invasive appraisal of the body composition has been executed with BIA analysis. The BIA has been lead on 96 subdivided skin-divers: 37 in static apnoea, 22 in dynamics apnoea, 17 in variable order, 20 in constant order. The stiffness has been determined with BIA analyzer to fixed frequency (50 khz). The subjects have been all invite to assume, in the 24 previous hours and during the tests, 2 liter of mineral water to optimize the state of body hydration.

Results

The search evidenced variation of the body water in all 96 subjects skin-divers. The Rxc carrier has endured a migration in longitudinal sense on the grafo RXC, indicating a body dehydration; there wasn't a meaningful loss of FM and BCM (there wasn't cross-sectional sense migration). BIA supplies consisting esteem of Rxc increase ($p<0.001$), after apnoea (value inversely proportional to the water), and meaningful loss of TBW and ECW ($p<0.001$).

Conclusions

The values of water loss have caught up a liter of lost fluid in some skin-divers, that to indicate as from a physiological point of view, without to catch up meaningful depths (static and dynamics apnoea) and muscular energetic consumption (static apnoea) (1), vascular and neuro endocrine mechanisms are activated to maintain in equilibrium the human organism. The carried out search has confirmed as it is necessary during training in apnoea, don't to forget to assume liquids waves to avoid one reduction of the psychophysical efficiency for loss of water (it is enough 2-3% of body weight) with consequent increase of the risks like syncope. As far as the nutritional aspect it is necessary to keep in mind that the liquids that forgiveness are rich in electrolytes (sodium in particular) (2), and that is enough to drink simple mineral water, drink little and often, without necessity to add some mineral integrator. Simple technique BIA for the survey of the body composition, can be considered like clinical gold standard, allows to find quantitative and qualitative variations in the human fluid and woven, opening therefore new spaces of research in the field of the immersion in apnoea.

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Breath-hold diving on an empty stomach is dangerous.

P. Lindholm

Swedish Defence Research Agency, Karolinska Institutet, 17177 Stockholm Sweden

Key words:apnea, exercise, drowning, diet, diving, breath-holding, hypoxia

The unstated goal of breath-hold (BH) diving is to avoid drowning by surfacing in time to start breathing before losing consciousness due to hypoxia. Normally with BH diving there is a strong urge to breathe, forcing most humans to abort a breath-hold within safe limits. This urge to breathe is mainly driven by the rising level of carbon dioxide that is produced from our metabolic processes. Carbon dioxide is produced when the muscles consume oxygen to burn carbohydrates and fat to produce energy for swimming. A recently published study by Lindholm and Gennser shows that a BH diver burning fat, after carbohydrate stores have been depleted, consumes oxygen faster with a resulting increased risk of hypoxia induced loss of consciousness.

<u>Prolongeg Exercise/Carbohydrate Store Depletion</u>

Prolonged periods of physical work deplete the carbohydrate stores (glycogen) in the body, which forces the body to compensate by increasing in the rate of lipid (fat) metabolism. When the human body burns fat to produce energy it uses 8% more oxygen than if it metabolizes carbohydrates. Also, 30% less carbon dioxide is produced by fat metabolism than carbohydrate metabolism. Thus, a breath-hold diver who has depleted his glycogen stores will become hypoxic faster, but the carbon dioxide driven stimulus to breathe will be delayed. A dive that could safely be performed in a rested and well-fed state may be dangerous after a long day of exertion from diving. The problem for the carbohydrate depleted BH diver is that the signals (urge to breathe, diaphragmatic contractions) of near breath-hold breakpoint that are recognized by the experienced divers as "it is time to surface" will be blunted, giving the diver a dangerous sense of comfort. Many recreational BH divers (spear-fishermen) spend hours pursuing their sport and fail to bring proper nutritional replacements.

<u>Conclusions</u>

The purpose of this abstract is to inform breath-hold divers of the potential increase in the risk of losing consciousness if breath-hold diving is performed after a prolonged period of exercise or fasting. For swimmers it seems advisable to perform breath-hold underwater swimming before other demanding physical exercise. Divers involved in underwater sports should take care to replenish their carbohydrate stores, for instance, during long competitions or a day of recreational spearfishing, both to increase performance and to reduce the above mentioned risk.

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Apnoea matabolism: modifications of blood glucose and urinary catecolamines

N. Sponsiello, R. Zenti

Scientific Committee of Apnea Academy, Italy

Key words:apnoea, blood glucose, urinary catecolamines,

One of the less common aspects of apnoea is the metabolic one. If people really understood what energy expenditure means, they would certainly recognize the safety limits of apnoea.

The study examined blood glucose concentrations in 80 skin-divers of different levels. The tests were performed before and after diving with constant weight (5 dives of 20 meters depth) and others before and after still diving.

The subjects who performed the constant weight formed 2 groups: 1) free diet; 2) fast. Those who performed still diving were measured only in fast condition, the rightest way.

The results reported significant decreases of blood glucose in the "constant weight - free diet" condition and in the "still diving - fast" condition. Less significative decreases were reported in the "constant weight - fast" condition. Quite frankly we can argue that these changes are approximately (95%) comprised between-13.4% and -2.8%, -13.1% and -3.0, respectively.The changes are not significantly different from zero for the datset "constant weight - fast".

The second part of the work examined urinary catecolamines as a consequence of 2 hour of repeated apnoeas in 8 subjects. The investigators compared the results with urinary catecolamines achieved few days after by the same subjects, in rest condition and with the same time intervals,. The results showed very significant changes, that means an average increase of 31,18% during the period of repeated apnoeas.It was only to be expected that the "constant weight" exercise involved a decrease of blood glucose, although the changes in the still diving exercise ought to be well considered.The enhanced production of catecolamines during constant weight apnoeas is a possible explanation of the high energy expenditure of this sport. It is well ackowledged that the fatigue of apnoea exercise leads to somehow personal and subjective behaviours; however if we carefully examine the results, we can easily argue that, on the biochemical level, all these signals proceed at the same rate. Obviously, everyone perceives these signals in a different way, according to different levels of exercise.

Hormonal modification and DCS in underwater Apnoeacolamines

R. Rossi[1], I. Parisse [1], F. Coscia[1], M. Malpier[1], M.R. Malpieri[2], C. Cordiano[3], L. Papandrea[4]

1 .Sport Medicine Specialization School - Medicine and Surgeon Faculty - University of Perugia, Italy
2. Superintendent of ICOT Underwater and Hyperbaric Medicine Centre, Latina, Italy
3. Accredited researcher for University of Perugia - Medicine and Surgeon Faculty - cardiology department, Italy
4. Immersion - Torino, Italy

Key words:apnoea, decompression

These are the results of a scientific research realized over a period of 5 years on a specimen of about 150 freedivers, both professional and amateurs, italians and foreigners, in open sea and closed water (lake or swimming pool), in adverse condition (dives under ice).

The results obtained have been matched with the ones of scuba divers, either with air or helium mixtures.the study and comparison of biochemical level acquired data, with cardio-pulmonary alteration due to breath-hold diving, pointed out how important cardio-methabolic parameters modify similar pathologies as myocardium infarction, cardiac engorgment decompensation and ictus cerebri.

Goal of the research was to verify hematics variation of some hormones strictly involved with the phenomenology of some clinical picture revealed in freedivers: it's a fact that, in these last years, we attended a remarkable growth of peculiar accident in freediving spearfishers acting deeper than 25 mt.The freediving methodology is almost typical for many divers: slow and prolonged breathing acts sequence on the water surface, lasting between 2' and 4', a quick descent to the bottom (sometimes with underwater scooters), a wait on the bottom between 50" and 1' 30" and a more or less quick ascent to the surface. Instead of the scooter the duck-dive system is used with a boat.

It's a matter of fact that many of these freedivers, after a certain amount of activity lasting several hours (5 hours, usually) may present a very deep neurological picture with a simptomatology practically superimposable to decompression sickness (DCS) (moreover, of an arterial gas embolism (AGE) and, in the handled cases, it reacts positively to hyperbaric therapy.

These are the symptoms learned: hemiparesis, paresis, sight desease, dyslalia up to aphasia, permanent neurological damage sometimes up to permanent invalidation of the subject and, in some cases, the death of the subject. The repetitiveness of such accident over the years, even happened more than once to the same subject, joined to the seriousness of others, to freedivers of any nation both pro and amateur, impose a task to the medical class of the underwater field: a deep reflection and, certainly, a critical essay on the physiopathology of the breath-hold diving, specially about the strict relationship that may occur between breath-hold and dcs.Particularly, they have been studied the variations of hematic concentration both of cardiac peptiydes (anp, bnp, cnp) and plasmatic cathecolamin, with blood sampling in basic condition pre-dive and then after a 5 hours deep spearfishing session (max depth -38 mt.) in bad atmospheric condition (with physical and emotional stress). Furthermore, blood samples were taken during static apnoea and dynamic apnoea in a swimming pool, both before and after the dive.in horizontal diving under ice a blood sample has been taken before reaching the high quota of the lake, before the dive and immediatly after the dive; in the same occasion we've used as a comparative parameter the blood samples of the scuba member of the rescue team, both male and female; at the same time studying cardiac volume variation.for the freediving constant ballast world recordman, alessandro rignani lolli, blood samples were taken before and immediatly after each dive, both during training days and the day of the record. at the same time, always before and after the dives, have been engineerized cardiac volumetric variations and oxygen arterial saturation due to blood shift, cardiac rythm and frequence alteration following hypoxic-hyperbaric stress learning that, in most cases, cardio-pulmonary modification due to blood shift will remain up to several hours from the end of the dive.

Friday December 2nd 2005
h.17:00 - 17:30

Keynoted Speaker

Claes Lundgren

Center for Research and Education in Special Environments (CRESE) and the Department of Physiology and Biophysics, School of Medicine and Biomedical Sciences. State University of N.Y. at Buffalo, Buffalo, N.Y., USA

The physiology and patho-physiology of breath-hold diving: unique or not so unique?

Keynote Speaker: **Claes Lundgren**

Center for Research and Education in Special Environments (CRESE) and the Department of Physiology and Biophysics, School of Medicine and Biomedical Sciences. State University of N.Y. at Buffalo, Buffalo, N.Y.

The physiology and patho-physiology of breath-hold diving: unique or not so unique?

Keywords: Breath-hold, diving, barotrauma, hypoxia, lung edema, hemoptysis, drowning

This presentation considers some aspects of the physiology and pathophysiology of breath-hold diving and is focusing on aspects related to depth and duration and drawing some parallels to conventional clinical medicine. It is a composite of observations and experiments by many different researchers.

The current depth record is reportedly 209 meters. The pressure (~22 atm) at this depth would reduce the gas volume in the lungs to ~1/22nd of the starting volume. This requires a very large redistribution of blood from the periphery into the intra-thoracic vasculature for pressure equilibration. Even during simple head-out immersion the central blood volume has been shown to increase by 0.7L. Volume-overloading of the pulmonary circulation is the likely explanation of swimmers' pulmonary edema. Furthermore, not surprisingly, there are reports of surfacing divers coughing up foamy blood-tinged sputum thus presenting a picture of capillary stress failure such as is also seen in severe cardiac backward failure .

Static-apnea competitors have reached breath-hold durations of just under 9 min. Does repeated episodes of severe hypoxia during training and competition expose these athletes to the risk of cognitive deterioration as has been observed in sleep-apnea sufferers? The diving response is important for breath-hold duration. The oxygen uptake from the lungs has been shown to be lower during breath holding by trained divers than the oxygen consumption when the same persons were resting and breathing quietly. The diving response relies on intense vagal tone, probably elicited by a pressor reflex triggered by a pronounced peripheral vasoconstriction and rise in blood pressure. During simulated wet dives by healthy divers in a hyperbaric chamber they exhibited systolic and diastolic pressures which were so high as to rarely be seen in the clinic even in cases of severe hypertension. During deep dives, the combination of cooling of the face, hypoxia, cardiac distension and increased cardiac pre-load and after-load is conducive to arrhythmias. Such mechanisms may also explain some cardiac fatalities due to certain terrestrial environmental challenges. Nonetheless, the omnipresence of the diving response among vertebrates (even fish!) suggests that it is biologically very valuable. It is particularly pronounced in small children and may protect against hypoxia during birth when the infant's head has been delivered and is cooled by the ambient air while compression of the chest and umbilical cord in the birth canal still interferes with oxygen supply. Moreover, it has been reported that the human diving response is potentiated by mental stress (a phenomenon shared with seals) and this may make a significant contribution to the remarkable survival times in drowning incidents in cold water which cannot be explained simply by reduced metabolism due to body cooling.

Friday December 2nd 2005

h. 17:30 - 18:30

Psychologic & Physiologic Aspects in Breath-hold Diving

Effects of apnea in social unease

C. Boscia, L. Veronese

Apnea Academy

Keywords: Apnea, social unease effects, evaluation therapy

The "apnea discovery", a didactic course of apnea academy, was proposed to 10 young people of a community for former drug addicts by instructor Carlo Boscia and his staff, with the support of psychologist Luisa Veronese.

During the 5 days' course there have been moments of group discussion centered on reflecting about emotions and feeling experienced during the day. The discussion was aimed at allowing people to acquire greater self knowledge from the experience, giving room at the same time to mutual comparison and sharing.

At the beginning of the course the following standard clinical tests were administered, in order to evaluate whether feelings like rage, anxiety and depression were present and prevailing:

- Staxi: it is an instrument supplying concise measurement of experience, expression and control of rage.
- Stai: this instrument is aimed at surveying and measuring anxiety, in order both to make psycho-diagnosis, and to verify efficacy and benefits of a therapy.
- Poms: this questionnaire allows to identify and quantify particular affectivity conditions, measuring six factors and as many mood-conditions: tension-anxiety,depression-dejection, aggressiveness-rage, vigor-activity,tiredness-apathy, confusion-bewilderment. This instrument has turned out to be a measurement sensitive to effects of various experimental conditions.

We have assumed that the feelings examined may have a strong resonance in teenagers that are facing a community course, and that an apnea course may supply them with instruments suitable to handle and control such feelings.

The tests were administered again at the end of the course to investigate, evaluate and analyze possible changes, and verify the emotional response to the experience.

The outcoming results indicate a significant change involving diminishing feelings of rage, anxiety and depression.

Mental and bodily approaches to sub aqueous apnea

L. Manfredini

Apnea Academy

Keywords: Psychology, sub aqueous apnea, autogenous training

Psychological techniques applied to sub aqueous apnea: Autogenous Training, Motor-Affective schemes modifications, Mental Training and Imagery, Relaxation in water, Bioenergetics, are proposed to athletes, during their complete sporting season. These techniques help athletes to achieve specific goals in every single phase of the training program, as to say the tactical, the technical, the physical preparation.

The purpose of this work is to demonstrate that these instruments are specifically adapted to the training and the competitive phases of the preparation.

It will be paid attention to the athlete self-control, self-management, self-regulation and self-monitoring.

Term self-control emphasizes the athlete capacity to control that everything goes well, to not be distracted, to inhibit "unsuitable answers", etc.In self-control knowledge are included abilities such as, to program one's own resources, to manage anxious events and to manage one's own humor, or pain reactions.

Self-management refers to the ability to produce appropriate behaviors.

Self-regulation refers to behavior and to underlying cognitive and physiological answers, and it does not simply describe obvious inhibitions or behavior adjustments, but it includes also subtle regulations of physiologic and psychological reactions.

The word self-monitoring lies to various case of behavior self-valuation.

Examples of psychological preparation in sub aqueous apnea will be supplied. Besides, during the competitive phase, some guidelines will be proposed for the individual psychological session.

Voluntary breath-holding in the morning and in the evening

G. Bosco, A.Ionadi, PG. Data and Mortola JP.[1]

FADAS Environmental Physiology Center, Section of Physiology, "G. D'Annunzio"
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Keywords: alveolar gases, apnoea, circadian pattern, metabolic rate

The aim of the present study was to determine whether or not voluntary breath-holding time (BHT) changes with the time of the day.

BHT with airways closed at end-expiration was measured in six male subjects in the sitting position during the morning (08.00-12.00 hours, on days 1, 6, 7 and 8) and evening (20.00-24.00 hours, on days 2 and 4).

BHT increased with the number of days of testing and, at day 8, the morning values averaged 160% of those on day 1. Also, Delta $PaCO_2$ [the difference between end-tidal partial pressure of CO_2 (PCO_2) and alveolar PCO_2 ($PaCO_2$) at the breaking point] increased in proportion to BHT. Hence, the BHT/Delta $PaCO_2$ ratio remained nearly constant.

Voluntary hyperventilation prolonged BHT and increased Delta $PaCO_2$. Conversely, in hypoxia (13% o2 for 1-2 h), BHT and Delta $PaCO_2$ were reduced proportionally. During the evening sessions, most of the BHT/Delta $PaCO_2$ ratios in normoxia, hypoxia or after hyperventilation were higher than the corresponding morning values, with the group difference reaching statistical significance for the measurements in normoxia and hypoxia.

In conclusion, voluntary BHTvaries in both duration and its relationship with Delta $PaCO_2$ between the morning and evening hours. The results should also imply that, with an interruption of breathing, changes in alveolar and arterial gases are not the same at different times of the day.

Saturday December3rd 2005
h. 9:00 - 9:30

Keynote Speaker

Guido Ferretti

Professor of Physiology
Université de Genève, CH

Respiratory modification in elite breath hold divers

Keynote Speaker: **Guido Ferretti**

Physiology Institute Université de Genève, CH

Respiratory modification in elite breath hold divers

Keywords: energy expenditure, lung volumes, breath-hold diving

Achievements in breath-hold diving depend, amongst others, on body oxygen stores at start of dive and on the rate of energy expenditure during the dive ($\dot{E}$).

An elevation of oxygen stores can be achieved through an increase in lung volumes. Total lung capacity (TLC) values above 9 liters were reported in several extreme breath-hold divers. Moreover the practice of glossopharyngeal breathing induced artificial increases in TLC up to 11 liters. Such lung volumes carry along an increase in the maximal diving depth, which is a direct function of TLC.

For different levels of during the dive, relationships between diving depth and TLC can be established. The resulting lines have slightly lower y-intercepts the higher is $\dot{E}$. This indicates that the depth a diver would reach by using only blood and muscle oxygen stores decreases with increasing $\dot{E}$. The slope of the lines is steeper the lower is $\dot{E}$. This means that the addition of 1 liter of lung volume would allow more additional meters to a dive, the lower is $\dot{E}$.

Reducing the metabolic rate requires a decrease in the energy cost of diving (C). The velocity (v) is directly proportional to $\dot{E}$ and inversely proportional to C. C in turn is equal to :

$$C = D / \eta \qquad (1)$$

where D is the drag, i.e. the force opposing the movement of a body in water, which depends on the water resistance and on the buoyancy of the body, and η is the mechanical efficiency of movement. Thus a reduction of C implies either a reduction of D, or an improvement of η, or both. Hydrodynamic research helps to lower D. The pursuit of better diving techniques may help to improve η.

Both the record dive to 100 m by Enzo Maiorca and that to 150 m by Umberto Pelizzari lasted 3.5 min. So the latter dive was carried out at a speed 50% faster than the former. This was indeed made possible by a greater TLC and a lower C in Pelizzari than in Maiorca.

Saturday December3rd 2005
h. 9:30 - 13:00

Physiopathology of Breath-hold Diving

Pulmonary edema in Breath Hold divers

F. Maggiorelli[2], D. Cialoni[1], N. Sponsiello[1], M. Tonerini[3], B. Frammartino[4]

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Keywords: free diving, breath hold diving, pulmonary oedema

Introduction

Since 90's literature reports papers describing a pathological condition, suggesting a clinical status of acute Pulmonary Aedema (EPA) both in free divers and scuba divers.

This work aims to analyse patho-genetic and physiopathologic aspects of EPA in breath hold diving, also referring to observed clinical cases.

EPA is characterized by an abnormal liquid accumulation in alveolar and interstitial lung spaces caused by hemodynamical defects inducing blood pressure increasing at lung capillary level, as in the heart failure conditions, or a direct increasing of the capillary and alveolar permeability, as demonstrated in the respiratory distress syndrome in the adult (ARDS). Generally EPA happens suddenly in a clinical status characterized by aggravating breathing difficulties, cough and haemoptysis.

The abnormal transudation of liquids jeopardizes the alveolar ventilation and the gas exchange at the lung level inducing a variety of hypoxia status up to the respiratory failure.

Materials and Methods

The methodology of clinical status documentation was one the firs target of the work. We refer to a methodology concerning a detailed documentation of the characterizing parameters (diagnostic images included) during the illness evolution from the acute phase up to the complete recovery (72 hours up to 10 days): the subject we took in care in our emergency and urgency department, with a clinical picture characterized by cough, dyspnoea thoracic constriction and conspicuous haemoptysis after breath hold diving. The declared reached depth was 36 meters.

We set up the standard instrumental examination normally used in routine control of acute EPA and it was continuously monitored the evolution of the clinical picture, with special reference to the pulmonary, cardiac, haematological and hsemo-gas pictures after few hours from diving, after seventy two hours and after ten days.

We performed the following instrumental analysis: Thorax TC, hemogasanalysis (EGA), haemachrome, electrocardiogram (ECG).

Results

A lot of significant indications were supplied by clinical tests; particularly the thorax TC after few hours from the dive, demonstrated an impressive alveolar effusion mainly located to the lung apexes and hilums.

The radiographic and clinical pictures markedly improved after 72 hours, with a complete regress after 10 days, without any medication. At the beginning of the illness the ECG showed pulmonary P waves due to right heart overload, tachycardia . EGA showed marked reduction of pO2 at respiratory failure threshold.

The obtained data have been compared to the results reported in literature where the documented cases refer the EPA of free divers and scuba divers as o particular aspect of EPA where the phenomenon is induced by an augmented alveolar permeability as that induced by immersion in cold water (1) or in subjects under heavy physical effort (2) inducing a great increase hydrostatic pressure inside the lung capillary, without any cardiac dysfunction. This pressure increasing seems to be induced by a secondary pulmonary hyper-perfusion to possible causal factors as the physical effort, the diving depth, the water temperature, the pressure compensation, the blood shift phenomenon, the dive suit, etc.

Discussion

Also if referred to few analysed clinical cases (in fact, only one was analysed with a detailed very accurate instrumental analysis) we think that the described experience should represent a start point to go in deep in analysing the EPA frequently affecting free divers.

Because of the impressive diffusion of free diving for recreational purposes in the last years, manly due to the increase of the marine tourism in the occidental countries, and the possible clinical situations here described, we think mandatory for the underwater medicine to deeply investigate the EPA induced by breath hold diving. A situation very harmful for the life and the health of the free diver that needs the scientific community to set up the necessary indication (guidelines) for an healthy practice of free diving..

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Epydemiological investigation on hemoptysis in Breath Hold divers

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Keywords: Epydemiological, hemoptysis, oedema, breath hold diving

Introduction

Symptomatology characterized by cough, a feeling of thoracic constriction, blood streaked expectoration and sometimes (regular) hemoptysis, combined or not with a certain extent of dyspnea, is frequently observed after one or more breath hold dives. That symptomatology is possibly in mutual relation with more serious or less serious kinds of sheer pulmonary oedema.

The investigation aims at assessing the prevalence of that clinical picture among breath hold divers. The investigation also aims at pointing out possible risk factors.

Methods and instruments

A retrospective research has been carried out on breath hold divers for assessing the prevalence and the possible risk factors of a clinical picture leading to (suggestivo di) a sheer pulmunary oedema.

Two questionnaires have been given out for that purpose. The first questionnaire (etero-somministrato) has been directed to a selected group of 212 breath hold divers, whom have been asked whether cough, hemoptysis or pulmunary edema have ever occurred after their breath hold dives.

The second questionnaire (autoamministrato) concerning personal, biometric, physiological and clinical data, information about breath hold diving, detailed data about cough, hemoptysis and pulmunary edema episodes has been given out to breath hold divers who had not been previously selected and it has been spread through associations? mailing lists and dedicated web sites.

Gathered data have been analysed to point out the overall characteristics of interviewed people. Relations among edema hypothetical risk factors have been sought afterwards and the risk (odds ratio) of edema related to risk factors has been estimated.

The relevance has been assessed with the (chi quadro) test ($p<0.05$).

Results

56 people answered yes to the question of the first questionnaire, those people account for 26,4% of interviewed people. 106 people have answered the second questionnaire

(95 males, 11 females; age ranging between 17 and 49; 52,83% were between 30 and 39 year old). 46 people out of those 106 have reported symptoms that may be related to a previous sheer pulmunary edema episode.
Significant differences from a statistical point of view between people who had previously experienced sheer pulmunary edema and those who had never complained symptoms of sheer pulmunary edema have not been pointed out analysing the questionnaires as far as age, gender, breath hold diving practised for years, smoking, allergies, playing other sports and clinical history are concerned.
A significant difference from a statistical point of view has been observed concerning the dive depth and significant information have been pointed out.Those information relate a broader probability of the episode of sheer pulmunary edema to equalization difficulties, stress and trouble due to pressure.
Analysing the questionnaires of the 46 people who experienced episodes of cough, blood streaked expectoration, hemoptysis and dyspnea it has been pointed out that 32% of them have affirmed that they had equalization difficulties, 36% of them have affirmed that they dived in a particularly stressful context and 54% of them have affirmed that they clearly understood when the problem occurred.
71% of those people have affirmed that the problem have occurred between the last metres of the descent and the maximum depth, 29% of those people have affirmed that the problem have occurred while resurfacing. Most frequently complained symptoms are cough accounting for 82% of people, dyspnea 51%, hemoptysis 82%.

Discussion
The analysis of gathered data points out that more than 26% of people who have answered the questionnaire have complained symptoms (leading to) sheer pulmunary edema during their breath hold dives.
Gathered data could point out a possible individual factor that induces the development of sheer pulmunary oedema.
Environmental factors such as the dive depth and the fact that the person is cold could be crucial for the individual factor.
Also psychophysical factors such as equalization difficulties and stress could be crucial for the individual factor.
Equalization difficulties and stress have proved to be significantly related to pathological episodes.

Stress of pulmonary gas exchange in breath hold dives

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Keywords: Gas exchange, carbon monoxide diffusing capacity of the lung, stress failure

The pulmonary blood-gas barrier is known to be very thin and at the same time is immensely very strong. It has been demonstrated several years ago that the capillary wall stress is approximately 7 x 105 dyn/cm2 and that the stress failure of the walls occurs if the pulmonary capillary is raised to abnormally high values. This can be the result either of an heavy exercise or of an increased mechanical load inside the lungs, stimulus which takes place in the condition of elevated ambient pressure. This dramatic event can explain the features reported by breath hold divers who descent at depth over 30 meters and show traces of blood in the airways, cough and dyspnea. These signs and symptoms are consistent with the disruption of the blood gas barrier and the consequent pulmonary edema and acute respiratory insufficiency. To test the hypothesis that the blood gas barrier can be stimulated toward its breaking point we measured the transfer factor of carbon monoxide immediately before and after a descent to 30 meters in 10 elicited breath holding divers, in order to search for the presence of an important pooling of blood inside the lungs. The central pooling of blood inside the lung can precede the dramatic scenario above described. When compared to the baseline values, the transfer factor measured immediately after an immersion to 30 meters of depth in the sea was increased on the average about 30% and in two cases over 50%. Most of the values recovered to the baseline in almost one hour. In one breath hold diver, who showed signs of dizziness when returned back to the sea surface, the transfer factor, measured after the test, increased severely and recovered after one hour. Another breath hold diver showed symptoms suspected for pulmonary edema consequent to lung injury. Chest imaging and blood gas analysis performed after two hours from the event confirmed the presence of patchy opacities in the two lungs at the level of superior and parahilar zones. The single breath carbon monoxide diffusing capacity, markedly increased after the descent, returned back to the baseline values after 5 days. He was hospitalized for several days and treated for the presence of respiratory distress syndrome. These results are consistent with the hypothesis that during descent there is an increase in pulmonary blood flow and pulmonary blood volume. The consequencies are an elevated mean pulmonary artery pressure and sign of pulmonary hemorragies which are entirely explained by the increase in the diffusing capacity. To date there are no randomized controlled

studies in the literature aimed to evaluate the frequency of these phenomenons as well as to study the outcome of the damage of both the pulmonary circulation and the parenchimal tissues after the injury among people practising these activities all over the world, but the conclusions of our study suggest to implement the knowledge on this field.
The Authors wish to express their gratitude to the Scuba Diving Team of the Fire-Department of Livorno for the precious support offered during the study.

Chemoceptive sensitivity to hypercapnia and hypoxia is markedly reduced in elite apnea divers

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Keywords:chemoceptor, apnea, elite divers, hypoxia, hypercapnia

The main drive for ventilation in human beings, under physiological conditions, is carbon dioxide (CO2) arterial partial pressure: a raise in arterial CO2, sensed by the central chemoceptors (located in the truncus, near the respiratory neural centers), and, to a lesser extent, by the peripheral chemoceptors (located into the carotid bodies and at the level of aortic arch), causes an increase in ventilation with a consequent increase in CO2 elimination and decrease in its arterial partial pressure. A secondary role is played by hypoxia, which elicits a similar, tough less impressive, effect by acting mainly on the peripheral chemoceptors. The individual chemosensitivity to hypoxia and to hypercapnia can be assessed by administering gas mixtures with different O2 and CO2 concentrations. Another possible approach is the rebreathing technique: in this case a progressive normoxic hypercapnia or normocapnic hypoxia can be obtained and the separate effects of hypercapnia (hypercapnic ventilatory response, HCVR) and hypoxia (hypoxic ventilatory response, HVR) evaluated in term of steepness of the regression slope between ventilation and the increase in end-tidal CO2 or decrease in oxygen saturation, respectively. The steeper the slope the higher the chemosensitivity to hypercapnia or hypoxia. Trained breath hold divers are able to keep apnea much longer than non trained subjects (group C). Our hypothesis was that breath hold divers (group A) are able to modify their chemosensitivity to hypoxia and hypercapnia in order to be able to stop ventilation for longer periods than non trained subjects. To assess this hypothesis we studied 12 elite breath hold divers selected by the "Nicola Brischigiaro apnea national school" (aged 33±4 years, mean±SEM) and 12 healthy control subjects (mean age 35±3 years). HVR and HCVR were assessed in all subjects by the rebreathing technique. Electrocardiogram, ventilation, gas exchange and oxygen saturation were continuously monitored throughout the maneuvers (Vmax by Sensormedics). As compared to group C, group A showed a dumped HCVR (0.25±0.09 vs 0.66±0.16, $p<0.01$) and HVR (-0.16±0.07 vs -0.37±0.08, $p<0.05$) and higher baseline end tidal PCO2 (40.6±1.6 vs 35.8±1.2 mmHg, $p<0.01$) despite similar baseline ventilation (12±1 vs 13±1 L/min, NS). These results indicate that chemoceptor sensitivity to hypercapnia and to hypoxia are significantly reduced in trained breath hold divers as compared to control subjects, explaining the ability of the former subjects to prolong apnea up to several minutes, and suggesting that a specific apnea training program can induce changes in chemoceptor sensitivity.

The role of functional endoscopic sinus surgery (FESS) for difficult sinus equalization treatment in free-divers

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Keywords: FESS, sinonasal disease, sinus equalization, free-diving, performance

Sinonasal cavities are usually directly coupled with nasal cavites in the normal human anatomy. This allows efficient equalization with external environment pressure, especially during free-diving. However, sinonasal disease and/or malformation may cause important difficulties in equalization, with subsequent sinus' damage and hamper of free-diving practice.objective of the present presentation is to describe a minimally-invasive surgical treatment (or fess) in difficult sinus equalization of free-divers.

Surgical inclusion criteria, treatment options, and surgical techniques are here described. in addition, direct free-divers case series are here exposed along with long-term results.

Significance of this lecture is the dramatic performance improvement in otherwise hampered free-divers, with state-of-the-art surgical solution of impaired sinonasal anatomy. This minimally-invasive and well-tolerated surgical treatment offers new broad horizons for free-divers and for everyone interested on this underwater practice.

HBO therapy in sudden hearing loss due to inner ear barotrauma

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Keywords: Hyperbaric ossigen terapy; sudden hearing loss; inner ear barotrauma

Sudden hearing loss (SHL) is a severe and widely common pathology which can be caused by different factors, including inner ear barotrauma (IEB).SHL is an irreversible pathology in almost 50% of cases resulting in a definitive hearing loss.

Among the therapies commonly used, HBO therapy seems particularly efficient in recovering of hearing functionality. Most physicians do not treat patients affected by SHL showing barotraumatic ethiology with this technique, worried that HBO can induce a further damage to the interested ear or affect the other.Barotrauma incidence is increased because of remarkable number of scuba divers since barotrauma risk is increased in first meters of dives.

The Authors, hypothesizing that the iatrogenic risk due to HBO can be controlled by clinical and technical methods, treated 14 pts. affected by SHL caused by IEB with HBO without iatrogenic adverse effects.

Blood lactate accumulation in static and dynamic apnoeas in humans

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Keywords: apnoea, exercise, lactate, anaerobic metabolism

A preliminary study of anaerobic metabolism during underwater swimming was carried out on six experienced breath-hold divers (4 males and 2 females, age 32+7 years, height 171 +1 cm, body mass 65.9+8.5 kg) performed maximal static apneas (S) and dynamic apneas (D) of increasing distance up to the maximum.

Blood lactate concentration (Lab) was determined by an electro-enzymatic method, in order to evaluate the contribution of anaerobic metabolism to the energy requirement of S and D. Resting Lab was 1.2 + 0.3 and 1.8 + 0.4 mm before S and D, respectively. After S, Lab was 2.2 + 0.4 mm. After D, Lab was higher the greater the distance. After maximal D, Lab was 6.8 + 2.2 mm. Assuming an oxygen equivalent for blood lactate accumulation of 3 ml/mM kg, the contribution of anaerobic lactic metabolism to the energy requirement of S and D was 196+119 and 1005+468 ml, respectively. The latter figure is some twice as big as previously reported on elite divers during deep breath-hold dives, a condition likely requiring a much lower rate of energy expenditure than underwater swimming. The average speed during D was 1.28 + 0.24 m/s. The rate of Lab accumulation was greater the higher the speed.

Two causes for Lab accumulation can be envisaged under the present experimental conditions : 1) performance of supramaximal exercise, and 2) occurrence of diving response.

The present preliminary data do not allow a clear distinction between these two components, because the energy cost of underwater swimming of the present subjects is not known. However, the demonstration of a significant positive relationship between Lab and speed during D suggests that the former rather than the latter may be the case. The performance of an accurate analysis of the energy balance of S and D in order to clarify this issue is justified by the present results.

Study supported by MIUR 60% and FNSRS grants to Guido Ferretti.

Respiratory rate can be modulated by long loop muscolar reflexes from small hand muscles

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Keywords: Respiratory control, Long Latency reflexes, Extreme Apnea

Neural respiratory control is still a matter of investigation nowadays. Since the 50's it's generally admitted that some muscular afferents are sresponsible for respiratory rate modulation. Those animal experiments had less confirmation in healthy humans. Since the 70's it has been admitted that group III and IV polymodal afferents can interfere by a non explained mechanism on respiratory rate in humans. Investigating a breath hold experiment after oxygen breathing (100% ; 30 min.) one of our subjects kept an apnea time of 13 min 54 sec. (in water 1,5 m depth). We mesured his alveolar gases percentage and concluded that they could not be the trigger for limiting the breathold time. We hypothetised that this could be explained by the muscular afferents theory even if the diver was not voluntarily contracting any muscle. In order to investigate the hypothesis we invited a group of subjects (8 males 3 females) to perform a fatigue test under two different contraction levels (25% and 50% of Maximal Voluntary Contraction) of a small hand muscle : Abductor Pollicis Brevis. The muscle is small enough to admit that his contraction will not be able to interfere with global VO2 of the subjet and also adequate to apply the Deuschl method for H reflex an Long Latency Reflex measurement. During the test, the respiratory rate was constantly recorded.

Results

The H reflex and the LLR significanly decrease during the fatigue tests. The dissociation between H reflex decrease and LLR variations is not present during the 25% fatigue test. This dissociation occurs in the same time range that the inspiratory rate increase ; the respiratory response is absent otherwise.

Discussion

Our results permit to discuss the presence of a long loop mechanism underlying respiratory rate control in humans. Accumulation of metabolites in contracting muscles should be the trigger ; even small muscles contracting at least at 50% of MVC and during at least 2 minutes of time cans induce respiratory response.

Electromyographic evaluation of free divers wearing relaxing bite

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4. Tecnico Ortodonzia

Keywords: free diving, relaxing bite, emg

Research Objective
The objective of the project was to detect possible variations of the masticator muscular tension in free divers wearing relaxing bite. The study was carried out by means of EMG evaluations performed before and after the use of the relaxing bite in order to verify its effectiveness in this specific sport.

Materials and Methods
Four athletes were selected, two males and two females, of age between 23 and 39 with similar characteristics in terms of training typology and agonistic level. Upon obtaining the individual informed consensus, the anamnestic and clinic evaluations collected in a specific clinic folder, which consists of both an orthodontic part and of a gnatologic part, allowed to exclude the presence of TMD (temporomandibular disorders). Indeed, each athlete was analyzed to verify the absence of present and previous painful symptoms, the absence of pain upon palpation, the absence of functional limitation (as demonstrated by the correct ranges of opening, lateral excursion e protrusion), and the absence of joint (and even provoked) noises. Each athlete was successively examined by two roentgen ray sessions (OPT e TRX L.L.) and a series of intra and extra oral pictures were taken; moreover, studying models inserted into the articulator were realized. After an initial EMG exam, each athlete was given a bite to be worn only at night for the first three months (8 hours), and during night time and during training sessions for the following three months (more than 8 hours). In order to quantify the changes of masseter and temporalis muscles tension, two more sessions of surface EMG recordings were made during the period of use of the bite on a three monthly basis. Each session consisted of three registrations, two of them were associated with maximum voluntary contraction and in rest position respectively, while the third one was made in free diving condition for a maximum amount of time of two minutes for each individual. The latter exam allows to assess the impact of the hypoxia on the muscular condition (as it actually occurs during a sport performance) as well as to evaluate the impact of the relaxing bite on the

muscular condition in order to validate its use in this particular sport. The EMG exams consist of the application of four surface electrodes to the right and left anterior temporalis and masseter muscles upon a proper skin cleaning and the detection of muscular fibres. In order to standardize the procedure, before the registration of EMG potentials two pictures were taken to document the electrodes position.The EMG recordings were made according to the following scheme: in maximum voluntary contraction (the patient can breathe); in rest position (the patient can breathe); in free diving, emulation for a maximum amount of time of 2 minutes for each athlete. The second EMG recording (after three months of nightly bite application) and the third EMG recording (at the sixth month, after three months of bite application during night time and during sport trainings) were complemented with a fourth registration which was performed in apnea for a maximum amount of time of 2 minutes (as in the first test) while the athletics wearing the relaxing bite.

Conclusion

Despite the unavoidable limits of the investigation due to the small size of the sample considered (because of the difficulty of finding homogeneous free divers not affected by TMD), such exams will allow us to assess the variations of EMG potentials in free divers wearing relaxing bites during breath as well as during free diving dry runs. Moreover, the results will provide us a consistent starting point to understand whether the use of bites during sport activity may increase muscular relax in the cranium-facial district, thus inducing enhanced agonistic performance.

Saturday December3rd 2005
h. 14:00 - 14:30

Sara Jane Pell

Aquabatics Research Team, Edith Cowan University; The Arts Catalyst, London

"Sub Culture"

Associated Research Proposal

"Sub Culture": Preparing a public subspace habitat performancer as an analogue to outerspace operations

S.J. Pell

Aquabatics Research Team, Edith Cowan University; The Arts Catalyst, London

Keywords: subspace habitat; space analgue performance; the art of diving

A critical consideration for long durational underwater habitat is the need to understand the specific consciousness of gravitational and aqueous conditions on human performance behaviours and limits. I propose this consciousness is a balance between the forces to affiliate and forces to withdraw from inner and outer spaces. An important question is just what this balance implies for the aquanaut and all related life support systems in subspace and how is it recognized and communicated.

This presentation introduces the considerations for developing a weep (wet extreme environment performance) that will be able to adapt technologies and systems across the physical sciences and to road test both the human life support and telematic performance systems required for the purpose of recognizing and communicating the specific consciousness of the encounter.

Pell will conduct a public weep habitat clinic at a depth of 1.5 - 2 ATA for 5days in an experiment called "sub culture" as an outerspace analogue performance for the exhitbition 'space soon' at the the london roundhouse, Sep 2006. (See: www.worldspaceculture.org) Pell will perform underwater operations of a utilitarian and aesthetic nature inside a purpose built transparent aquarium while she, and her life support systems and personnel will be visible to a live audience that comes and goes.

The live performance conveys a paradigmatic shift between two epochs: cultural and ideological and the aesthetical spheres and medical scientific concepts of the body entity and site. The performance also provides direct public social implication research opportunities and live data with predictive validity for longer durational habitability unhindered by the challenges and limitations of remote ocean operations.

The methedologies of the study will be discussed including phase one investigations to harness and modify current technologies. "Sub culture" will include a period of preliminary trials to tailor and test modified free flow helmet designs and apparel to accommodate built-in-bio fluid and nutrition replenishment systems, waste disposal and bio monitoring devices to quantify the life support operations and human movement possibilities for the development of a longer public performance. Phase two includes a psychophysiological study aimed at understanding the specific consciousness and the corollary towards behaviour and performance limits and any links to hyperbaric decompression effects in such uniquely controlled conditions. Various sub-research strands include psychometric responses to confined space habitat conditions; neurological function in neutral buoyancy; spatial orientation/ navigation; movement memory function; communication systems; bio-psychological response; oxygen therapy, pressure tissues and dermo saturation analysis over the performance period itself.

Participation in discussion will be encouraged and an open call will be made at blue2005 for researchers to submit associated research proposals and recommend linkages to this project.

Pell will consider and discuss possibilities for research between april - dec 2006 related to:

- disclosure to data variables & pre/post-performance discussion
- non-invasive bio monitoring systems i.e. dopler and psychometric profiling tests
- qualitative technological testing including prototype appraisal
- 24hr video, audio and systems monitoring and recording & live audience viewing

It is hoped that these investigations will lead to models that clarify the functional architecture of the different physiological and psychological regions of the performative sites. Both normal and abnormal behaviours including performative and the natural behaviours are to be analyzed. The intention is to form bridges between biological, physical and aesthetical systems notably the perceived actions and consciousness that describe aspects of weep self-organization, performance, and behaviours.

December 2nd 2005

Mauro Ficini

Young Investigator Award

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The BLUE 2005 Organizing Committe is pleased to host the first Mauro Ficini Award.

Professor Ficini, cardiologist, was university teacher of Apnoea Physio-pathology at the post-graduated school of Underwater Medicine at the Chieti University, directed by Professor Pier Giorgio Data, and was one of the founder of Apnea Academy.

The prize in his memory is offerd by the “Mauro Ficini Association” to award 1000 Euro to the best paper in the field of “Apnoea physiology”, to allow and encourage very talented young investigators keen on in this fascinating research field to further investigate on the physiological limits of breath hold diving

E’ con piacere che il comitato organizzativo del congresso ospita il primo Premio Mauro Ficini.

Il Professor Ficini, cardiologo, è stato docente di fisiopatologia dell’apnea alla scuola di specializzazione dell’Università di Chieti, diretta dal Professor Pier Giorgio Data, e anche uno dei fondatori di Apnea Academy .

Il Premio in danaro, della somma di 1000 Euro, messo a disposizione dalla “Associazione Mauro Ficini” verrà consegnato al lavoro più meriteviole riguardante la fisiologia dell’apnea presentato al congresso ed è in memoria di Mauro Ficini, affinchè lo studio affascinante dell’apnea subacquea e dei suoi limiti possano progredire nel tempo, attraverso la passione e il talento di nuovi giovani ricercatori

December 1st - 3rd 2005

Poster Sessions

Cerebellar ischemia, an unusual complication of decompression illness: case report

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Diving and Hyperbaric Medicine Unit - Misericordia Hospital - ASL 9 Grosseto

Keywords: Decompression Illness, Hyperbaric oxygenation

The patient was a 45 years old male, professional diver, long experience in diving . He dived at 39 meters (4,9 ATA) for multilevel dive of about 25' and surfaced following the dive profile of the computer. At surfacing he complained very severe fatigue, hypotonia and general malaise. He was unable to climb on the boat and so his buddies recovered him; on the boat he became unconscious, but he was still able to breathe by himself and the radial pulse was weak but present. He was rushed to the nearest harbour and after 2 hours referred to our Unit. At the arrival he was tetraparetic, very confused but conscious, very severe general weakness, headache and sleepiness.

The sistolic pressure was 90 mm. Hg.. He was then recompressed to 2.8 ATA (18 metres) with US Navy table 6 with a very quick recover of motor strength on upper arms and a slight hypotonia on inferior limbs which was more severe on the left leg, the headache disappeared and the patient was totally awake and able to speak correctly; he was still unable to void and so an urethral catheter was positioned. With a very quick load of fluids (about 2500 cc.) the sistolic pressure raised to 130 mm.Hg. Table 6 was then completed with extensions and at the end of the treatment he was able to walk; at physical examination we observed ataxia and incoordination of the gait and moderate hypotonia on the left leg and bladder paralysis. He sustained "tailing" treatments of HBO and after 15 days he recovered almost fully, being able to walk without problems and to void (residual bladder hyperreflexia).

The brain MRI after 10 days showed (300)no significant cerebral problems but identified an area of slight cerebellar ischemia in the area of perfusion of the posterior cerebellar artery.

A transoesophageal Doppler for detection of patent foramen ovale was totally negative.

Contrast trans-toracal ecocardiografy (CTTE) for diagnosis of patent foramen ovale (PFO)

F. Di Donato, A Balboni, E. Nasole

Iperbaric Center M.P.M. of Bologna

Keywords: contrast trans-toracal ecocardiografy; patent foramen ovale

Medical literature indicate that exists a positive correlation between de-compression illness (DCI) after scuba diving and PFO. CTTE is a sensitive, safe and repeatable technique that Authors suggest to use for PFO diagnosis in scuba divers performing diving over the range of advanced certification, where there is a high risk of generating silent bubbles. Our job reports the use of CTTE in the diagnosis of PFO in 4 cases of DCI.

Health effects of exposure to marine aerosol: epidemiological survey on general population sample living in Livorno

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Keywords: Marine aerosol, respiratory health effects, asthma, GIS

Background

In 1998 - 2000, the Italian multicentre survey ISAYA (Italian Study on Asthma in Young Adults) was carried out through a questionnaire on a random population sample (n = 18.873, age 20 - 44 yrs) in order to estimate variations in the prevalence of asthma and asthma-like symptoms and in order to investigate the effects of climate and atmospheric pollution in the prevalence of respiratory diseases (De Marco et al, 2002)

. Statistical analyses carried out among the towns of Livorno, Pisa and Lucca (involved in the ISAYA survey), showed that the prevalence of asthma is higher in the seaside town of Livorno.

We have supposed that the sea can influence and increase respiratory diseases (asthma and asthma-like symptoms) of the resident population through the marine aerosol.

In fact, the pollutants, derived from column of water, are accumulated in the surface microlayer and then, they are transferred through the wind from water to atmosphere. Signals of pollution are evident in samples collected in the sea in front of Livorno at different distances from coastline. The sea-surface microlayer and the sub-surface waters are enriched with alkanes, phthalates, polycyclic aromatic hydrocarbons (PAH) and suspended organic matter. These substances are transferred to the atmosphere by marine aerosol that is enriched particularly in the finest particles (Cincinelli et al, 2001).

Aim

Tto evaluate the relation between the exposure to marine aerosol and asthma and asthma-like symptoms in the population sample living in the municipality of Livorno (n=1146).

Methods

By GIS (Geographical Information System) technology, the study area was divided in 3 zones according to different exposures to marine aerosol.

The first zone (high exposure) is within 300m from the coastline; the second zone (medium exposure) is situated between 300 and 1000m from the coastline; the third zone (control) is located between 1000m from the coastline and the municipality borders. The subjects were attributed to the different classes of exposure according to the location of household residences through GIS.Statistical analyses were carried out through SPSS stratifying the population sample according to the classification.

Results

Logistic regression models, adjusted for independent effects of age, smoking and job titles, showed a statistically significant association of living near the sea (0-300 metres from coastline) for attacks of asthma in women (OR = 3.75, IC to 95% : 1.34 - 10.48).

Conclusions

Adverse respiratory health effects of living near the sea have been observed in women living near the sea Validation of these subjective findings through objective tests is necessary to further investigate the relationship of marine environment with health.

Therapeutic tables in decompression illness and arterial gas embolism

C. Antonelli

Scuba Diving Istructor

Keywords: Decompression illness, arterial gas embolism, therapeutic tables

Decompression illness (DCI) has low incidence if compared to the big number of dives, anyhow, if we consider the great deal of divers at different levels, the total number of registered accidents is relatively large. Furthermore this disease declares often in an unforeseeable way. Therefore the treatment assumes a primary role expecially the hyperbaric therapy that is the basis of this treatment.The choice of the correct therapeutic table for each case is, consequently, very important. Existing therapeutic tables are various but can be briefly summarized in:

- low-pressure (2.8 ATA) short tables with 100% oxygen breathing gas;
- high-pressure (4 or 6 ATA) tables with nitrox or heliox breathing gas;
- saturation tables, whose most important characteristic is the long recompression time.

For a correct choice we should consider, over all, the delay of recompression time with regard to first symptoms and the severity of case.

Authors' opinions about ideal therapeutic table are various and sometime conflicting but, on analysing casuistries, we can declare that low-pressure oxygen tables administration resolves almost all the cases, if the recompression takes place within a short time.

When recompression is possible almost immediately, it is of remarkable importance the mechanical effect of reduction on bubbles volume due to pressure; in these cases high-pressure tables can be considered. These tables can be used also in severe spinal-cord decompression sickness replacing the previous ones.

It is still disputed which one is the breathing mixture to prefer. Actually heliox seems to find the greatest agreements because it causes less problems during recompression of divers who had breathed oxygen-helium gas mixture and, over all, because nitrox can cause narcosis and gives a further contribution of nitrogen.

Saturation treatment must be used only when there is a real life risk, in patients treated with considerable delay or when exacerbation of symptoms during 18 meters recompression appears. It remains, however, an extreme option and logistically it is very difficult to apply and not everybody agrees on this kind of treatment.

In cases of arterial gas embolism (AGE) cerebral injury it is recommended to start with an initial 6 ATA recompression only if the time between symptoms arousal and recompression beginning is less than few hours.

Diabets and Breath hold Diving: management of a diabetes case type 1 during a course instructors

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Keywords: Glicate hemoglobin HbA1c, Am.Diabetes Ass. ADA, Body Impedance an.BIA

Aim:

1. To demonstrate the suitability in a good control diabetic person, free from complication, to carry out a complex sport activity like the underwater apnea.
2. Acknowledgment from the main prelocated underwater associations to didactics and to emergency .
3. Definition of a common protocol to scientific and professional organizations.

Materials and methods

Male 43 years old, type I diabetic from 22 years, in intensive insulinic treatment (5 injections die) admitted to a course for apnea instructor in the year 2002. The practical and theoretical course had the duration of 10 days and was articulated in daily theoretical lessons of 3-4 hours, and in practical lessons for a total of 4-5 hours day. The glicemic control before the course was represented from a HbA1c of 8%, with a satisfactory daily glicemic profile, and with normal nutritional values (normal BMI and body composition). There were no complications in action in the respect of ADA protocol (2). Management of insulinic therapy previewed lispro insulin before meal and insulin NPH to lunch and before bedtime. The glicemic control was done in the morning before breakfast and before and after the activity in the sea. The diet foresaw breakfast with carbohydrate prevalence, one dulls (fruits) during the morning , "a light" lunch made up of carbohydrates, protein and fruits, and supper where it was attempted to give preference to proteic foods beyond that to carbohydrates, vegetables and yields. Mineral water were assumed during the day in order to integrate high losses.

Results

Glicometabolic control (HbA1c) was not improved in the successive control after the course (HbA1c 8% vs 8.2%), the body composition measured with BIA has found a greater state of loss of total water, with a loss of lean mass (Body Cellular mass 34kg vs 32,8) and light weight loss (BMI 24,2 vs 23,9), in agreement with scientific jobs carries out on not diabetic subjects (3). There were no changes in cardiovascular, renal, neurological and retinal system. The hypoglycaemias were not much, dealt with simple sugars, but plus frequent have been the hyperglycaemias, dealt sometimes with small additional doses of fast action insulin (10-15% of total) (1). The management of the nutritional aspect has not been particularly difficult if not for the not costant timetables. Conclusion: we didn't find direct clinicians advantages neither on the metabolic control, neither on the evolution of the complications: the apnea activity does not make "bad" to diabetes, but not ago " well " to diabetes. Which are the advantages then? Sure in terms of selfcontrol and wellbeing: apnea is a fascinating activity under many aspects, it is a hard activity in terms of energetic and mental expenditure (4) and that demand physical efficiency, theoretical knoweledge, technical preparation, concentration and self-control.

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Use of a Customised Snorkel: Clinical Considerations

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Keywords: snorkel, temporomandibular joint

In 1999, after many years of experience matured as a breath-hold diving, world champion Umberto Pelizzari a new kind of snorkel was designed. It had to prevent periodontal problems to which a conventional snorkel mouthpiece causes. The recurrent use of a snorkel during various training sessions caused periodontal and occlusal problems, temporomandibular pain, discomfort, and stress. Currently, after 6 years of use, it is possible to verify how those dental problems have decreased in the observed subject and how the prolonged use of the customised snorkel has produced better comfort, less stress to the muscular apparatus in the maxillo-facial district, less dysfunction of the temporomandibular joint (TMJ) and evident reduction in periodontal diseases.

Materials and methods

All the clinical steps and the laboratory phases needed to construct the customised snorkel for the analysed subject are described. The orthodontic examination, the photographic documentation (intraoral and extraoral photographs), the wax bite, the facebow and the dental casts were collected, as well as the radiographic examination, such as the panoramic radiograph, the lateral cephalometric with its tracing, the transcranial radiograph of the TMJ.

Discussion

The literature does not mention the snorkel's effects on the breath-hold diver, but some references to the mouthpiece are made. As the intraoral part of the two devices is similar, conclusions on the consequences on the TMJ and facial muscles may be taken. Previous studies found that up to 65% of divers suffer from TMJ dysfunction associated with the use of a diving mouthpiece. It was suggested that discomfort and pain to the TMJ may lead to local inflammation of the TMJ, which can progress to labyrinthine dysfunction and associated vestibular disturbances such as vertigo and disorientation. Furthermore, given the close contact with the tympanic membrane, difficulties in compensation may occur. All commercially available snorkels force the athlete to hold the mandible in a forward position in order for the incisors and the cuspids to grasp the mouthpiece. The resulting effect is a lack of posterior support and uneven pressure application within the TMJ and associated muscles. Therefore, the posterior thickness may improve the neuro-muscular equilibrium leading to an increase in strength and muscular resistance. The customised thickness of the snorkel mouthpiece produces effects similar to those generated by occlusal splints, already used by many athletes in several sports e.g. (athletics, rowing, skiing, motor-cycling, fencing, etc.).

Conclusion: the customised snorkel:a) assures more retention so that the athlete's effort to grasp it is greatly reduced; b) fulfils the athlete's expectations reducing the risks of TMJ dysfunctions; c) is more comfortable avoiding the sensation of muscular tension which is frequent after the recurrent use of snorkel; d) has a posterior thickness similar to that of the occlusal splint which makes its debut in the breath-hold diving field.

Hitting by a boat during freedive practice: clinic case

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Keywords: hitting by boat, personal lesion, valuetion of damage

The intent of this work is to define from a forensic point of view the accident happened to two freedivers while practicing, evaluating the long time consequences of the injuries. The accident took place on the 18th of August 1986 in Sardinia, precisely at the Porto Taverna beach, 12km away from Olbia. In order to shelter from the strong wind, a boat with six individuals on board was trying to find a bay 50m away from the beach, with calmer sea. In order to fix the anchor, the 16 years old RM, soon followed by the 18 years old friend D.R., dived into the water wearing only the mask and fixed the anchor at the depth of about 2m. Both the young men succeed in their intent in a few minutes, but because of the strong wind neither them nor the remaining people on board heard a motorboat arriving.

Because of the current the two young men were at about 10m from the boat. The motorboat, ignoring navigation rules, hit them causing them extensive wounds. More precisely, the blades hit R.M. on the back and arms, while D.R. was hit on the face and the right shoulder. The motorboat immediately stopped to help D.R. who was taken to shore, while R.M. for a misunderstanding was left in water and got to shore by himself. Taken to the nearest hospital, the two young men were cured as their conditions required: with extensive sutures of the wounds (140 stitches for R.M. and 70 for D.R.). Penal prosecution did not take place because of an amnesty: if this didn't happen the scars on the face of D.R. would be classified as serious personal wounds (ex art. 583 C.P.), both because of the long time recovery (more than 40 days) and the permanent lesion on the face.

Analogously for R.M. the wounds could be classified as serious personal wounds because of the long time recovery, weather the scars on the back, not compromising any function, could not determine permanent consequence of penal relevance. From a civil point of view, the permanent lesions of D.R. were of the 20% and those of R.M. of the 13%.

Importance of neuropsychological model of attention in apnea mental training

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Keywords: mental training, attention, prefrontal lobe.

Introduction

Attention as a psychical function makes selection of perception, cognitive materials and equalizing affective ambient.

Neuropsychological model of attention means hierarchical intergrated brain systems:

1) aras - structure for global activating brain cortex,
2) thalamic efferent system is perceptional related cortex activating system,
3) prefrontal lobe whose activities results in attention selectivity, selection of mental contents that results with highest form of mental activity - self consciousness.

Apnea mental training means applying of meditation,autogenic training, yoga-pranayama, nlp…, in order to improve psychical functions (attention, concentration, perception, thinking, affectivity, motivation).

Methodology

Quality of attention posibility has been tested using batteries of psychological and neuropsychological tests which tap attention and memory(tests of short time memory, digit span wechsler scale, serial adding test, trail making test a and b).

Results

The significant better achievement on digit and visual span tasks of wechsler memory scale revised form and tmt a and b were shown for subjects who performed mental training.

Conclusions

Mental training improves psychic selection possibility of, desirable or not, perceptual, cognitive and affective mental contents, also improving attention and concentration. prefrontal lobe make selection of perceptual contents, directing mental activity on desired cognitive contents (thoughts and memories), having a main influence on informational traffic through limbic system, determining affective and motivational status.due to importance of mental equilibrium during apnea performance, obviously, the prefrontal lobe has a key role in brain attention system and mental training of apnea.

24H Scuba diving test: cognitive responses and psychological profile

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Keywords: diving, stress, ansiety, exstreme environment, psycology

Aim of the study

Analyze which role can be played by some personality traits as per the anxiety stress observed arising while performing under extreme sport conditions.

Materials and methods

We report cognitive responses and psycological profile as obtained during a scuba diver's 24 hrs underwater performance.

The subject was analyzed in a swimming pool [3.94 ft of h2o - 11.77 kpa.; @ 84.2-89.6 f] and HR and O_2Sat. values were continuously monitored without showing any significant variation.three ones were the psycological tests we applied: cattel 16 pf, poms - mmpi (the former was submitted in the pre-dive phase, while the latter group was used during the immersion).

Results

Both cattel 16 pf results (our pre-dive test) and poms ones (one of the inter-dive tests we applied) were as expected in an athlete exposed to these extreme environmental conditions: equalized and performance oriented.

On the contrary mmpi test has shown an unexpected increase as per the compiling time value (8 hrs. instead of those 45 min. usually required).conclusions:anxiety while scuba diving is a very subjective occurrence: significantly varying i.e. when a low self-esteem or an emotional instability be there.

Tight methabolic monitoring during recreational scuba diving in type 1 diabetic patients

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Keywords: diving, stress, ansiety, exstreme environment, psycology

Introduction

Type 1 Diabetes Mellitus is commonly considered a contraindication for scuba diving, mainly due to the risk of hypoglycaemia. The "Submerse Diabetes" Project was launched by our Center in 2004, and recently adopted as a "Special Project" by DAN-Europe. Our aim was to demonstrate that, with a thorough practical and theoretical training specifically targeted on the diabetic state, well-controlled, non complicated diabetic patients can safely dive, without medical and metabolic additional risks. In two OWD Courses, organized in 2004 and 2005, integrating the traditional educational program with additional modules, we led 14 young diabetic subjects to obtain the first-level diving licence, without technical or medical problems. The following step was then to verify the efficacy and safety of the adopted protocol during normal recreational diving. In a residential 5-day stage in the isle of Ventotene (Italy), a group of previously trained diabetic divers took part in "DEEP MONITORING", an intensive program of consecutive dives, where technical, physiological, metabolic and endocrine parameters were strictly monitored.

Methods

Six well-controlled, non-complicated type-1 diabetic patients (3 M, 3 F, age 32.3±7 y, duration of illness 10.7±3.3 y, HbA1c 7.2±0.9 %) participated in the study. During a 5-day period in September 2005, 2 dives/day were scheduled for each subject. Blood glucose (BG) levels were controlled by intensified SMBG (at least 8/day). Before each dive, BG was checked at -60', -30', and -10', and corrective measures (extra insulin or CHO) were adopted if necessary, according to an algorithm based on BG absolute levels and dynamic. Another BG control was performed immediately after emersion. When

BG >300 mg/dl, blood ketones were tested with a meter. During days 3,4 and 5 an external device for continuous s.c. glucose monitoring (CGMS®, MEDTRONIC, expressly modified for the purpose) was applied and worn also during immersions. Samples for urinary and salivary Cortisol and Catecholamines were taken before and immediately after diving in days 3 and 4. Main diving parameters were recorded during all immersions with "Black Box" dive computers. Precordial Doppler for air bubbles was performed 20' after immersions.

Results
Data have been gathered from 56 dives (maximal depth 23.0±3,1 m, time 44'± 18", minimal water temperature 20.2±1.7); 4 of the programmed 60 dives were missed for reasons not related to medical or technical problems. Mean BG before diving was: -60': 211.3±69.9, -30': 206.5±68.6, -10': 211.8±66.1 mg/dl. In 37/56 (66.1%) some correction was necessary, according to the adopted security protocol: in 25 cases supplementary CHO; in 9 cases extra insulin doses; in 3 cases both CHO and insulin. No problems occurred during dives, except for minimal hypoglycaemic symptoms (cephalea) in 3 occasions in the same patient. Post-dive glycemic values were 175.9±88.3 (7 >300, 4 <70) mg/dl. Due to technical problems (1 flood, 1 wire accidental damage, 2 signal "overflow", probably consequence of defective wire waterproofing), CGMS recording were available for only 21/36 dives: data showed a progressive lowering of glucose concentrations from the beginning to the end of dive (200.7± 57.5 to 173.1±71.2; - 13.9%). Looking at the 24 h CGMS profiles, all glycemic indexes resulted significantly higher in the diving days than in a control monitoring performed 2 weeks before (mean BG, time and area under the curve above normal limits,). No significant bubble formation was evidenced by Doppler examination.

Conclusions
These preliminary data suggest that in well-controlled, complications-free young diabetic subjects, SCUBA diving can be performed without additional medical risks, when applying a rigorous protocol for preventing acute metabolic complications, based on serial pre-dive glycemic determinations. This result can be obtained at the expense of temporary rise of glycemic parameters, not determining a general worsening of metabolic control in the medium term.

New approaches to the prevention of decompression ilness

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Keywords: Radiology, apnea, chest Xray

Recent experiences on apnea divers have shown interesting and peculiar alterations of cardiopulmonary physiology.

In particular, relevant effects of stressed conditions have been recorded by means of electrocardiography and echocardiography, performed at a depth of about 20-30 meters; changes in pulmonary physiology have been evidenced by direct observation, as well as by spirometric measurements. Such studies have shown a behavior of these stressed human organs comparable to some well known physiopathologic problems.However, many pathologic events are diagnosed just studying the final effects, with no direct evidence, such that provided by chest roentgenology: lung volume reduction, blood shift, increasing of intravascular blood volume, enlargement of both right and left heart, and the appearance of pulmonary opacities compatible with pulmonary edema.

The implementation of an underwater radiologic lab requires the overcoming of many technical as well as radiological limitations due to the different environment where the acquisition is performed. Among them:

- environmental safety, including both the exposure doses and the electrical risks;
- standard acquisition protocols, included the correct distance focus-patient;
- physical effects of the water medium on the Xrays and consequent need of suitableenergies for the generation of suitable photons;
- safe engineering of the acquisition system, to guarantee the diver and to allow typical projections of chest radiography;
- resistance of the instrumentation to depth physical conditions;
- skilled personnel.

The overcome of these feasibility limitations will be the result of a strict cooperation of engineers, physicists, physicians and involved industrial partners.

Feasibilty analysis of a radiological lab for underwater thorax evaluation

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Keywords: Radiology, apnea, chest Xray

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Cardiovascular changes to "Diving Reflex"; comparison between divers and non-divers in dynamic apnea

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Keywords: Radiology, apnea, chest Xray

Introduction
The aim of our study was to compare highly trained divers with a control group in order to assess differences about chronotropism and inotropism.

Materials and methods
Six male divers were compared with 6 male controls. By impedance cardiography, data of cardiac output (CO), heart rate (HR), stroke volume (SV), ventricular ejection time (VET) and SV/VET were collected during three different experimental sessions: 40 seconds of breath-hold exercise in water (A), air (B) and an exercise with normal breathing (C).

Results
During trial B, HR decreased earlier in divers, namely from 15th to 25th second of apnea. CO showed a 20 % difference between groups at 40th second during trial B. While SV/VET in apnea in water did not reveal any difference between groups, apnea in air was caractherized by an increment (40 %) in divers with respect to controls. Discussion. Divers showed a faster response in bradycardia and also in myocardial inotropism. Frank-Starling mechanism and prolonged diastolic time may explain the inotropic response observed.

Conclusions
The more rapid cardiovascular response noted in divers seemed directly related to the degree of specific training and emphasized by the breath-hold manoeuvre in air with respect to apnea in water..

Emergency treatment of diving casualities in the Tirrenian coast

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Keywords:Decompression Illness, Hyperbaric oxygenation

The tirrenian coast is located in Tuscany and has a large number of diving site, mainly the isles of Elba, Giannutri, Giglio, Capraia and the neighbours of Monte Argentario. So we have 3 hyperbaric facilities located in Pisa, Grosseto and Portoferraio.

Since 1999 we have the Regional Helicopter for Emergency Medical Service (HEMS), which has greatly improved the time of medical evacuation of the patient from the site of the accident to the hyperbaric facility.

We have treated, in the period of time from 1997 to 2004, 385 patients (average number of cases 47 for year), a percentage of 16% of the average number of cases of Decompression Illness (DCI) which have been treated in Italy every year.

In our hyperbaric facilities we have a common protocol for the referral of the patient to the chamber, which is based on the collection of the informations about the kind of dive performed, fluidotherapy (either orally or intravenous) and normobaric oxygen breathing. If the patient is referred by HEMS is mandatory not to exceed the height of 1000 feet (300 meters).

In a very high percentage of treatment we use US Navy Oxygen Treatment tables (mainly TT 6).The outcome of the patients after the first treatment has been complete cure in the 90 % of cases and we have a negligible number of cases with permanent neurologic sequelae.

We have a very close collaboration with the Emergency Department and we have trained all the personnel involved in Diving First Aid.

Indice

Authors

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