proportion of the workload in a civilian chamber. At Fremantle[7] for instance in 1990, 41 divers received 119 treatments in a total of 1808 patient treatments, i.e. 6.6% of the total workload. In Adelaide[8] over the same period, 20 divers required 69 treatments in a total of 792, a strike rate of 8.7% of the total workload.

In the reports from both these units, the figures for divers are quite separate from the other conditions treated. To suggest that treatments for divers and non-diving conditions are grouped together to boost the figures is grossly misleading.

I am grateful to Mr Cummins for bringing these problems into the open where they can be discussed. The problems have arisen because of a lack of communication between the agencies, the instructors and some of the outspoken diving medicos.

After a week of being incarcerated with the SPUMS group in the Maldives last year, both before and after he presented his paper, I believe that Mr Cummins returned with opinions significantly different from those he presented in this paper. All these problems were discussed and many points of mutual agreement were reached. If he was now asked to present such a paper I expect its content would be vastly different. Unfortunately I fear that others may still harbour his original misconceptions, which is why this reply has been written.

There has always been a standing invitation to all Associate Members of SPUMS to attend the Annual Scientific Meeting of the Society. In this they are no different from the full members. The response to date has been disappointingly poor and has perpetuated the "us and them" mentality. Those few Associates who have attended have enjoyed the meetings, achieved some benefit and have reconciled many differences. I exhort all members of the diving fraternity to join us this year in Port Douglas or next year in Palau. It must be remembered that we all have the same goal, safe diving.

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DIVING FITNESS

Glen Egstrom

Introduction

I am by profession a kineseologist. We study how people perform in a variety of different circumstances. Diving fitness has been discussed from a variety of points of view for many years. Strength, endurance and the specificity of training are cornerstones for fitness and have justifiably been given the lion's share of the attention. People make remarkably specific adaptations to the imposed demands of the environment and continually seek to gain equilibrium with the stresses applied in training programs. That is a long winded way of saying that just because you are in good physical or medical condition for a particular activity it does not mean that you are in good condition for some other activity. Specific adaptation takes some time. It is not something that happens immediately. The barriers which face the scuba diver, who wishes to perform safely, are biomechanical, physiological, methodological and psychological.

Biomechanical fitness

The Japanese Ama (breath-hold) divers have strength in the functional muscle groups that enable them to force themselves down in the water. They take some incredible kicks and drive themselves down until they become negatively buoyant and then they work their way to the bottom. As young adults, these females work in water depths of 10 m for periods of 6 hours a day in water temperatures similar those off the coast of New Zealand and California. As they become more proficient, they develop the strength to be able to go down to about 30 m on breath hold dives. On the 10 m dives they do one dive about every 2 to 3 minutes, on the 30 m dives they do one dive every 4 to 5 minutes. They do that for 6 hours and they take 30 minutes off for lunch. It is a

specific adaptation that most people could not manage. Because they do these dives on a regular basis, they acclimatize themselves and consequently they are able to do it quite comfortably.

The would-be diver faces an interesting challenge. Browning, in the play "Heracles", said that "a man in armour is his armour's slave". The diver has the same basic problem.

A scuba diver can be described as a person about to become involved in heavy exercise who covers the nose with a mask that eliminates nose breathing and then covers the body with a bulky rubber suit which retains body heat, but restricts motion at every joint and causes the body to float significantly. This person then attaches fins to their feet which makes walking difficult and requires a unique kicking style if propulsion through the water is to be achieved. The musculature involved in kicking is likely to be stressed at points in the range of motion where strength may be weak.

This handicapped the person attaches a 20 kg package of weight to the back of the torso with a variety of straps so that the centre of mass of the body is raised 15-20 cm. A host of hoses is attached to the tank on the diver's back. These hoses will provide breathing resistance, water resistance and information relative to the diver's life support status.

After this the prospective diver attaches 7-11 kg of lead to the waist in order to sink the rubber suit and the body under the water. Finally the diver attaches a knife, watch, depth gauge, goody bag, camera or spear gun to the body.

The question we have to ask is "What does this do to performance and what do I have to do in order to make myself fit to be able to handle it?" We put ourselves into exposure suits. Thick neoprene rubber restricts movement. Every joint is going to have to operate against this resistance. The individual who has sufficient strength to be able to wear it like a second skin and has sufficient endurance to be able to pay the energy costs, will not have a problem. Wetsuits have different mechanical problems to drysuits. As a consequence you need specialized training and specialized adaptation to whichever of these suits you are going to use. If you are in a cold water area and you know that you are going to dive in a drysuit it makes absolutely no sense to train in a wetsuit. Train in a drysuit if that is what you are going to dive in. If you train in a wetsuit, use a wetsuit or take another training course in a drysuit before you go out and create a problem for yourself using one.

Individuals who make a switch from non-wetsuit diving to a wetsuit find that they get very tired, very quickly. Many complain about the restriction on their chest, saying "I can't take a deep breath". After they have done it for a while, they either develop some additional strength or learn to tolerate the discomfort. Both biomechanical and physiological issues are associated with strength and endurance which are very important aspects of being fit to dive.

Biomechanical fitness implies that the individual is capable of handling the equipment much as if it were a second skin. This is usually an easy task underwater as the diver becomes nearly neutral following descent. However the topside efforts, under the influence of gravity, may well cause over exertion. The fit of the equipment is also a contributing factor since poorly fitting equipment can cause loss of range of motion, increased drag and increased workload.

We tend to hang things all over our body. A friend of mine has an octopus, a pony bottle, a regulator, gauges, a camera, a snorkel, and hoses hanging everywhere. It is a small wonder that he has turned to photography. All he does now is sit on the bottom and take macro shots of coral heads. But if he had to do anything other than that, he would find that there is a good deal of stress to diving with all that equipment. My dive buddy today, has started to hang things inside his stabilizing jacket, which makes a great deal of sense. It cuts down on the frontal surface area and the drag co-efficient and make it much easier to swim. Usually divers just add another clip and hang something on it.

Physiological fitness

Physiological fitness requires the development of adequate strength and endurance to be able to meet the demands of a particular dive.

As a scuba instructor I have been frequently told by individuals who come into my classes that they are a fitness buffs They run miles every day. Unfortunately the functional muscle groups that are used in the running are not the same as are used swimming. Swimmers move from the hip and use the knee in a way that we do not normally do when we run. So strong muscles for running may do us little or no good when diving.

Strength is best gained at that point in the range of motion of the muscle movement where the highest resistance is met in the activity that is being undertaken. Thus fin swimming requires special preparation in order to be able to handle the resistance developed by the large fins used in scuba.

Endurance is largely cardiovascular in nature and is more generally improved under overload conditions. Medical fitness is very important since a surprising number of would-be divers are not aware of the potential risks associated with going diving without an adequate medical evaluation. The late Dr Jefferson Davis laboured for several years on a consensus guideline on the medical examination of scuba divers with the assistance of nearly 100 doctors drawn from the majority of specialties in medicine. This work[1] is

particularly helpful to those not skilled in hyperbaric medicine.

The cheapest insurance in terms of being fit for a dive is to be able to demonstrate that you have adequate fluid balance. Jeff Davis had a really marvellous solution to this. You know when you are adequately hydrated when your urine is clear and copious. Fluid balance has become one of the hot topics in sports medicine over the last four or five years. We have found that performance is seriously degraded under conditions where the person is under-hydrated. The total circulating blood volume goes down. The blood is more viscous. Sludging occurs. It all makes it more difficult to circulate blood through the tissues. We found that we get better performances from people on treadmills when they are well hydrated then when they are dehydrated. As divers we have negative pressure breathing, cold, a little dehydration from alcohol, coffee and respiratory water loss, all impinging on our ability to balance our water budget.

Discussing hydration and dehydration, there is always the question "How much water should I drink?". One glass of water is not enough. About a litre an hour can move from the stomach into the blood. If you are dumping fluid at a faster rate than a litre an hour, you are not going to keep up. We have to hydrate, not only before dives but between dives, in order to maintain a reasonable degree of fluid balance to be able to handle the exercise conditions that we have when diving.

One of the few things that my students at UCLA ever remember me for is giving them advice about hangovers. If when you finish partying the world is not as it should be, then you should drink three 8 ounce (250 ml) glasses of cold water. Then you go to bed and go to sleep. When you get up during the night you drink another 8 ounce (250 ml)glass of water. You will be remarkably clear-headed in the morning.

The diver has to be able to deal with the stresses that follow the introduction of the body into water under different kinds of workloads with various kinds of conditions. We can recognize the mechanical problems, so we need to have enough strength and endurance to be able to cope with them for two purposes. One is to enjoy at a comfort level our diving. Secondly to be able to deal with the sudden demands for survival. These are two quite different issues.

The comfort level is really easy. Remember that the resistance through the water, goes up as a function of the square of the velocity. If you are steaming along you will increase the resistance at a considerable rate.

Comfort includes being able to use breath control all the time during the dive. It also includes being worry free. A trapped air hose is a real threat to survival. When a diver suddenly becomes aware that his air supply is going to be cut off his pulse rate suddenly climbs to about 170 beats a minute, which is excessive. His equilibrium, his comfort level, has been seriously disrupted. Stress now starts to take a real hold on his performance and he is more likely to make mistakes. As soon as the hose is free, the threat is gone, and as soon as the threat is gone the pulse rate comes down.

Swimming into a current is hard work. If the current is one knot, the majority of people are not going to be able to swim against it more than about 50 to 90 seconds. It pushes our oxygen uptake up to its limit. In our lab studies we find that reasonably well trained people can operate at that level for 40 to 50 seconds. Highly trained athletes might be able to last another 10 to 15 seconds. That means that if you have got to swim hard to catch up with the boat or the Jesus Line you only have a short spurt available. If you miss it and are swept away and keep trying, you may jeopardize yourself because you will not be able to keep going. It becomes important to recognise that if we are going to have to have strength and endurance, we need to exercise the functional muscle groups needed to provide the strength and endurance at an appropriate range of motion. Riding a bicycle does not prepare you well to operate with mask, snorkel and fins in the open sea. If you want to prepare yourself you should be using the functional muscle groups, that you know you are going to use, in the way in which you are going to use them. Being in good shape for running is probably not going to guarantee that you are going to be in good shape for swimming hard against a current.

Methodological fitness

Methodological fitness means using the proper techniques to insure effective and efficient performance. Once the technique has been chosen then it must be over-learned until errors are essentially eliminated. After that, problems which occur can be addressed without having to think about the execution of fundamental skills.

We should always ask ourselves the question "Is this the best way we can do that ?". This becomes particularly important when dealing with emergency procedures. With a methodology that is relatively simple, straightforward and has been rehearsed a bit, you can expect it to be able to work. If, on the other hand, you are using a methodology that is not over-learned or is not appropriate it may be doomed to failure.

Surf passage is a piece of cake if you do right. It can be life threatening if you do it wrong. Heart rates in the range of 180 have been measured during such events and sadder, and hopefully wiser, divers have been dragged ashore because they lacked the capability to continue under their own power.

Teaching novices to enter 0.9-1.2 m surf we tell them that the only way they are going to survive is by meeting force by force or by avoiding the forces that are coming in. All waves roll when they come ashore. The water moves in

a circle, in, down and out. If you dive into the base of a wave, you will be carried under the wave and up on the back side. The individual who stays upright in the face of a wave is going to catch all the white water and all its force in the face. It knocks one over and washes one up the beach. We tell people not to stop in the drop zone. Either go out, by going under, or come back and take care of yourself.

The point is, if you have not totally learned the skills you may not really know what to do. As a consequence you stay there, do nothing and hope for the best. Under those circumstances, a small wave has sufficient force to knock you over and roll you back up the beach.

Knowing what to do and when to do it is extremely important. I mention this because, in many of the things we take for granted, we run into this same problem. How many of you learned buddy breathing using the one regulator passed back and forth? If you had been trained by some of the agencies in recent years, you will not have been taught to share air from a single regulator. But if you were taught, how many of you practised buddy breathing five times or 10 times or 15 times in the basic course?

It takes a lot of practice to acquire a skill like buddy breathing, so that you do not make a lot of mistakes. We studied a beginners' class. When they could buddy breathe satisfactorily kneeling on the bottom we asked them to swim down the pool wall and turn and swim across the pool. As they were going the down the wall an instructor would deprive one of the students of their air. We did it as part of our stress training. At that point, they were out of air. So they went into their air sharing approach. It took 17 to 21 trials before they got right. The commonest mistake was when they made the signal "I'm out of air, I want to share", they would stop swimming and sink to the bottom. Not only did it take 17 to 21 trials before they could do it properly, but we found that if they did not reinforce that skill, every six months, they would go back to sinking. If you have not practised buddy breathing in the last six months you may have a degradation in performance as a result.

How many of you have practised intentionally ditching a weight belt in the last six months? You may say that all one has do is pull on the quick release and the belt goes. In fact, that is not correct.

If you are lucky and the belt slides free after flipping the buckle, that weight belt will slide down your body. Assuming that it has a clear drop path, it may even separate.

A number of you have been given a weight belt that would fit a Sumo wrestler and I have noticed that you just thread the long tongue through the buckle and clip it. There is about a yard of belt sticking out of the side. This is a potential mechanical problem. The buckle pulls away for quick release. As that belt starts to drop the belt no longer withdraws straight out of the buckle. The droop of the belt makes it mechanically thicker, which increases friction against the buckle and it can literally re-close itself. The enlarged loop falls down and hooks on the knife on the outside of the leg. Now instead of being able to take a big kick, the diver is doing little "loop" steps because of the weight belt. I suggest that it is incompatible with good health. It is a mechanical problem and we have to be smart enough, as divers, to avoid that kind of thing.

If you are in in a horizontal position and you open the buckle on you weight belt is it going to fall off? No, a weight belt will not fall off in a horizontal position. The diver has to roll or pull it free. We have done a series of tests of weight belt ditching over the years on manikins and found that if you are more than 30° from vertical, the weight belt will not drop if all you do is open the buckle. It will only fall off if you go into vertical position and can dislodge it. When an individual goes upright the tank comes down and presses firmly against the cleavage of the buttocks. That holds the weight belt in position. You have to flex the trunk and move the tank away or do a positive ditch, pull it away. That is a skill that has to be practised. If you do not learn to do it reflexly, you may not do it at all because you have other kinds of problems beginning to interfere.

Over the years about 70 or 80% of diver fatalities still have the weight belt firmly fixed on the hips when they are recovered. In one incident a man had the weight belt hanging on a crotch strap between his legs. His girlfriend came down trying to disengage the thing, and they both perished. Ditching a weight belt is a skill, like any other thing that you learn. Over-learn the skill, so that you can do it with either hand as a positive ditch. That is not only do you loosen the buckle, but you get the weight belt free and away from the body so that it can drop clear.

People who consistently swim in a head down position are kicking to make up for the fact that they are underweighted. They are using more energy because they have to fight buoyancy on every single kick in order to keep themselves down. On the other hand, those who are leaning forward are over-weighted and are using energy to keep themselves moving through the water to keep themselves up. If you are correctly weighted for the depth you are diving at, you can hold a position parallel to the surface with little or no energy being expended.

Psychological fitness

Psychological fitness in diving is often the most difficult to achieve. The ability to relax and enjoy underwater activity is foreign to many participants in the sport. Each dive, for some, is a victory over adversity and the notion that they cheated death yet another time provides a surge of exhilaration that stimulates them to try again. As the comfort level in diving increases, the diver becomes a waterperson, a comfortable citizen in the world under the sea. Stress is

minimal and the fear of the unknown is replaced with anticipation for another great dive.

A changed clientele has created a special of kind of problem for instructors. Instead of having waterpeople to train as divers, we now have a population looking for another recreational pursuit. Many of them are not waterpeople. They are people who come from varied backgrounds. When we take them underwater they are bound to have increased levels of stress if they are normal.

What is it that actually makes us stressed? We gave a group of engineering students a lecture on Boyle's Law, Henry's Law, Charles' Law and how they would operated on a person in a recompression chamber. We told them that when you are compressed it gets hotter and that under pressure, your ears are going to be painful. Then we told half of them how serious it was going to be, what they had to in order to be equalize their ears and that if they did not equalize early and often enough they were likely to rupture their eardrums and that if they did not exhale while ascending they were liable to lung rupture. We put them into a chamber, closed the door and banged the catches tight. What they did not understand was that we were putting them in an altitude chamber, not a hyperbaric chamber. We blew hot air into the chamber. We had a beautiful brass gauge where the needle went right around and redlined at 100 ft of seawater. We were able to sneak a little bit of air in, about half a p.s.i. so that they would feel the pressure on their ears. They dutifully went through all the manoeuvres to get themselves organized. We put them through a series of psychological tests. The performances of the ones who thought that they were in a really bad situation got slightly better the longer they stayed in there and more uncomfortable they became. Those that we did not tell anything to did not have any serious problems in the beginning. But the longer they were in there and the hotter and the more uncomfortable they got, the more their performance went down. What this says is that if we do not deal with stress as a recognised factor, then we are going to have people who may have a distorted view of what is going on.

How do we recognise stress? Things do not look normal. If you look at your buddy and see widely dilated pupils and a steady stream of air coming out of the regulator, it is a clue that your buddy is not happy.

People have fears, usually groundless, that sharks and moray eels are going to bite and that the wild abalone is going to trap fingers, so they will not be able to get off the bottom. All these kinds of things contribute to stress. Stress brings on a syndrome. This syndrome is abnormality, they do not look right. At this stage we have do something to help improve their outlook because if we do not, they are going to go into panic. Panic is blind, unreasoning fear.

People who are going to become divers must have the capacity to be able to exercise self-control even when things start to turn bad. An individual who has the head, shoulders and arms up out of the water has an unusually high level of work. The head weighs about 8 kg (17 pounds), the arms and shoulders are probably another 16-18 kg (35 or 40 pounds). Try treading water with your fins with both arms and shoulders out and see how long you can do that and stay happy. It is about 40-60 seconds if you are in really good shape. Then propulsion slows and the body sinks. By this time you have discarded your regulator because you could not get enough air through it and now you have water in front of your air passages. This creates further excitement, you rear back out of the water and cough and splutter and sink again. After two or three of these immersions you start to lose a lot interest in what is going on. At that point, in many instances, the diver is perfectly willing to give up the whole business. It is not a conscious decision but it is the decision that is made.

Conclusions

We need to recognise the stresses that are associated with the density of water, the work of breathing and moving, temperature changes, gear related issues and a whole series of emotional issues. Motivation to dive is important. If people do not want to dive, it is very difficult to teach them how. If they do not want to solve problems because of their fear of death or whatever, they do not do well in courses of instruction. With that personality type you would be doing everybody a favour by suggesting that they learn how to ride motorcycles or do something where gravity is the only thing which they have to deal with.

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This is an edited transcript of a lecture given by Dr Egstrom when he was the guest speaker at the SPUMS 1991 Annual Scientific Meeting.

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